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# Between a rock and a hard place: European energy policy and complexity in the wake of the Ukraine war

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## Abstract
Despite increasing political tensions, the major European economies have done little to strengthen their energy security prior to Russia's invasion of Ukraine, in February 2022. Shocked by Russian atrocities, Western nations condemned the war and decided to support Ukraine's effort to defend its territory. Beyond quantifying EU's dependence on Russian energy imports and explaining how this dependence came to be, this paper analyses the multifaceted implications of Europe's efforts to regain its energy sovereignty. A comparative vulnerability study between Germany and Lithuania complements this analysis, highlighting two fundamentally different ways to approach energy security issues and tackle the looming energy crisis. What will become apparent in this article is that: trade cannot be a panacea for bridging political divides; the war and the policy announcements that accompany it place unprecedented burdens on Western economies; a country's historical background plays – as the German-Lithuanian case demonstrates – an essential role in crafting its energy security strategy and in its readiness to act in crisis situations; and the accelerated deployment of renewable energies and other measures aimed at steering European economies away from Russian fuels encounter barriers that cannot be solved with political will alone, they also require breakthroughs in power storage technologies and extensive investments in critical infrastructure projects.

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## 1 Introduction

Over the past decades, the European Union (EU) maneuvered itself into a strong dependence on energy imports from Russia. In 2020, the EU imported, for example, more than four fifth of its fossil-fuel demand and almost its entire nuclear fuel from countries outside the Union. Among these countries, Russia was the EU's largest supplier of fossil fuels and its second largest supplier of nuclear fuels (Eurostat, 2022a; ESA 2021). Cheap fuel imports from Russia helped European economies flourish, but also made these economies extremely vulnerable to supply disruptions, allowing the autocratic Russian government to put them at risk (Borrell, 2022). Despite early warnings [E.g., the annexation of Crimea in March 2014, the escalation of Russo-Ukrainian conflict in 2015, and the large movements of Russian troupes and military equipment near the Russo-Ukrainian border in 2021.], extensive energy security plans [E.g., the European Energy Security Strategy (EU, 2014).], vast scholarly literature about economic interdependence and increasing mistrust between Europe and Russia [E.g., Högselius (2013); Kundnani (2014); Copeland (1996); Copeland (2015); Krickovic (2015); Gustafson (2020); Sziklai et al. (2020); Groitl (2021); Tajoli (2022); Mariotti (2022).], Russian fuels were "too attractive to resist" (Högselius, 2013, p. 200), and major European economies have done little to reduce the Union's vulnerability to Russian energy imports prior to February 2022, when Russia started an unprovoked war of aggression against Ukraine. Indeed, since 2014, when the European Commission announced the EU's *Energy Security Strategy*, the Russian imports of natural gas – the commodity that bears the highest potential to harm the Union's economies – increased by more than 50% [I.e., from 3,620 PJ in 2013 to 5,631 PJ in 2020 (Eurostat, 2022e; EU, 2014).]. In addition, calls to stop the gas-pipeline project Nord Stream 2[1] did not hinder the German, Dutch, French, and Austrian companies BASF/Wintershall, E.on/Uniper, Shell, Engie, and OMV to invest in this huge Russian pipeline project (Gazprom, 2015; Gustafson, 2020); Germany did not stop its chemical giant BASF to transfer assets relevant for the nation's energy security to Gazprom;[2] France and Spain decided to cancel the MidCat pipeline project that would

[1] Nord Stream 2 is a second offshore gas pipeline that has been built under the Baltic Sea to connect Russia to Germany. In contrast to the onshore pipeline connections between Russia and Western Europe, the offshore pipelines Nord Stream 1 and 2 bypass all Eastern European countries. Fearing that Russia might weaponize energy by disrupting the gas supply along the offshore connection, these countries called to stop the Nord Stream 2 project (Sziklai et al., 2020, p.11). The USA also tried to stop the construction of the Nord Stream 2 pipeline, arguing that a second offshore connection would double the gas transport capacity and increase Europe's dependence on Russia even more. However, the motivation behind USA's engagement was also driven by the country's desire to find a market for own exports of shale gas and to replace a portion of the EU's imports from Russia.

[2] Gazprom is a vertically integrated natural gas corporation controlled by the Russian state. Though a complex asset swap with BASF, Gazprom became the sole owner of major gas storage facilities in Germany and Austria and 7,000 km of critical gas-transport infrastructure in Germany. In addition, Gazprom acquired through this transaction significant shares in the gas markets of Germany, Belgium, France, the Netherlands, Denmark, Czechia, and Austria (Wingas, 2017).

have allowed the transport of non-Russian gas from Spain to Northern Europe;[3] Germany's Federal Antitrust Authority (Bundeskartellamt) approved three days before Russia's invasion in Ukraine the transfer of Shell's stakes in the PCK refinery to Rosneft;[4] and this list could be continued with several other delayed or abandoned infrastructure projects aimed at strengthening the EU's energy security, or cases of complex entanglements between major European and Russian companies. In other words, "Europe is an empty box in terms of energy […] and never thought about a strategy for energy security," as Claudio Descalzi – the CEO of the Italian utility ENI – said in March 2022 (Reuters, 2022a). Shocked by the war's atrocities, Western nations condemned Russia's aggression and decided to support Ukraine's efforts to defend its territory (EU, 2022b). Yet this is easier said than done, because the EU finances with its energy imports the war it so vehemently condemns. In addition, each time the EU policymakers try to ban Russian energy imports, they face the moral dilemma of weighing own losses in livelihood against more war victims in Ukraine (Independent, 2022; Bianco et al., 2022). Indeed, as Hungary's reluctance to agree on banning Russian oil imports and the skepticism of Germany and Italy regarding a gas embargo have shown, Member States that expect higher economic burdens from sanction packages against Russia, are also more likely to question and/or oppose them (Gordon, 2022; GCEE, 2022a & b; Agora Energiewende, 2022b). Beyond quantifying the EU's dependence on Russian energy imports and explaining how this dependence came to be, this paper analyses the sanctions against Russia, their multifaceted implications, and the Union's efforts to regain its energy sovereignty, highlighting the problems related to the accelerated deployment of renewable energies. A comparative vulnerability study between Germany and Lithuania complements this analysis, unveiling two fundamentally different ways to approach energy security issues and tackle the looming energy crisis. What will become apparent in this article is that that (1) the war in Ukraine and the policy announcements that accompany it place long lasting burdens on Western economies; (2) trade cannot be a panacea for bridging political divides; (3) no invisible hand will somehow align profit-seeking with energy security goals; (4) a country's historical background and its geographical location play – as the German-Lithuanian case demonstrates – an essential role in crafting its security strategies and being prepared to act in crisis situations; and (5) a robust political consensus is not enough for steering modern societies away from fossil fuels, to be successful, the transition towards renewable economies also requires breakthroughs in power storage technologies, extensive investments in critical infrastructure projects, and innovations in all economic sectors.

[3] The MidCat pipeline is listed in EU's *Energy Security Strategy* as relevant infrastructure project for reducing EU's vulnerability to Russian gas imports (EU, 2014). Yet despite this fact, France and Spain stopped the project in 2019, due to high costs and lack of utility.

[4] Rosneft is an oil corporation controlled by the Russian state. By acquiring Shell's shares in the PCK refinery, Rosneft increased its stake in the refinery from 54.17–91.67%. The remaining 8.33% are hold by the Italian utility ENI (Spiegel, 2022a; RBB, 2022).

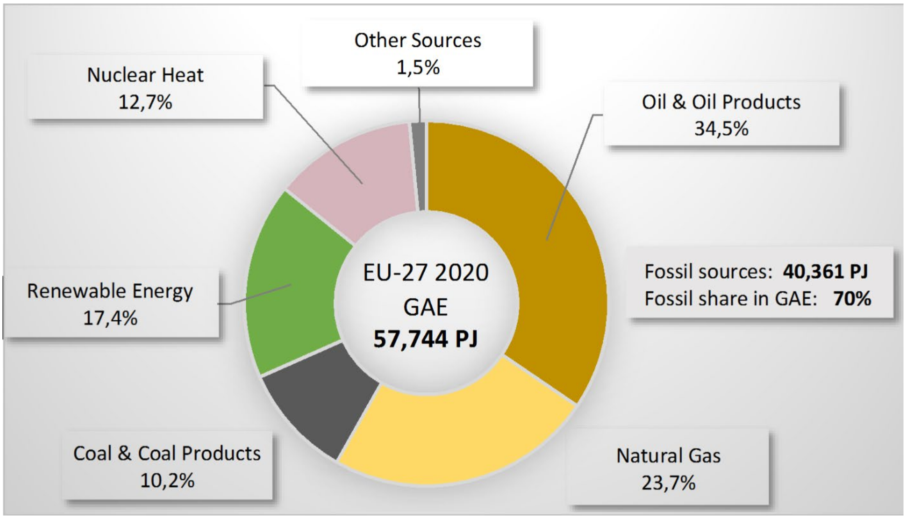



**Fig. 1** EU-27–2020: Gross Available Energy. Shares in Gross Available Energy by Source. (Data Source: Eurostat (2022a & e))

## 2 The age of decarbonization and Europe's dependence on fossil fuels

Two decades ago, the European Union (EU) pledged to reduce the greenhouse gas emissions (GHG) of its Member States to levels that "prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1998, Article 2; EU, 2002). Therefore, EU policymakers agreed on long-term and intermediate decarbonization goals; established action plans for deploying renewable energies, increasing energy efficiency, and trading GHG emission allowances; defined sub-targets for all these categories of action; and implemented a plethora of rules, regulations, incentive-mechanisms, and tools aimed at steering their economies away from fossil fuels. Yet despite achieving its intermediate energy and climate goals for 2020 in all categories [I.e., reducing GHG emissions by 20% from the 1990 levels, achieving a renewable energy share of 20% in gross energy consumption, and increasing energy efficiency by 20% (EU, 2009).], the EU still depends to a large extent on fossil energy resources. Indeed, with 40,361 petajoules (PJ), fossil fuels accounted in 2020 for 70% of EU's gross available energy (GAE) (see Fig. 1). [5]

In addition, the EU is poor in natural resources and all its 27 Member States are net importers of energy (Eurostat, 2022a, p.4). This explains why extra-EU imports – i.e., imports from countries outside the EU – are indispensable for meeting EU's energy demand. In 2020, non-EU countries supplied about 82% of the EU's fossil-fuel demand and 95% of its uranium demand (Eurostat, 2022a, b, & c; ESA, 2021, p.

[5] Since January 2021 (Brexit) the EU encompasses 27 Member States. If not otherwise specified, all EU figures in this paper refer to aggregated quantitative data for these 27 Member States (i.e., for the purpose of this paper the terms EU and EU-27 are equivalent).

14). Among these countries Russia was for more than one decade EU's largest supplier of oil, natural gas, and coal (Eurostat, 2022a, p. 5).

Irrespective of diverging national interests and sometimes conflicting views regarding the most effective instruments for mitigating climate change, EU policymakers stood united behind the promise that their countries' energy supply would remain secure and affordable during the transition towards low carbon technologies. Yet while implementing, monitoring, and steadily amending the European energy and climate legislation, integrating additional activity sectors to their initial decarbonization plans, agreeing upon more ambitious targets, and paving the way for carbon neutrality, EU policymakers lost sight over their promise that energy would remain affordable and took the security of their countries' energy supply for granted (EU, 2019; GIE, 2022; Sturm, 2020, pp.183–190).

The extreme increase in global energy prices experienced in the second half of 2021 and the ongoing aggression against Ukraine started by Russia in February 2022 significantly altered the European energy-political discourse, shifting its focus from mitigating climate change to securing the EU's energy demand and protecting vulnerable consumers against soaring energy prices (Leopoldina, 2022; GCEE, 2022a & b; Koenen et al., 2022).

## 3 "Change through Trade" and the resulting global order

Despite their ideological divide, Western and Eastern economies got extremely intertwined over the past five decades. How did this come to be? Why did many liberal democracies rush into a strong dependence on the unfriendly authoritarian Russian regime? The answer to these questions lies in part in the energy hunger of the developed world and the simple fact that natural resources are abundant in Russia, while they are scarce in Europe and other regions of the world (Högselius, 2013, p.5). But beyond their desire to access scarce resources at low costs, Western nations considered their economic involvement with the Soviet bloc as a means to overcome ideological barriers, forge trust, and induce political change (Högselius, 2013, p.105; Krickovic 2015, p.4; Gustafson 2020; ARD 2021).

Driven by the hope of reunification, Germany was one of the early proponents of diplomatic and economic solutions for diverging political views. Its "rapprochement" concept – later known as "Wandel durch Handel" or "change through trade" – can be traced back to a speech of the Social-Democratic politician Egon Bahr from 1963 (ARD, 2021). "Wandel durch Annäherung" or "change through rapprochement" – was West Germany's first attempt to recognize East Germany after World War II. The "Passierschein" – a document that allowed West German citizens to visit their relatives in East Germany – was the first result of Germany's "rapprochement" effort (ARD, 2021). In 1969, Bahr's political concept became part of Germany's *Ostpolitik* – a policy of reconciliation with the Soviet Union – and has since constantly been on the agenda of all German chancellors from Willy Brandt to Olaf Scholz (ARD, 2021; Kundnani, 2014; Gustafson, 2020, pp. 70–71; Högselius 2013, pp.105–131). Gustafson (2020, p.69) writes, for example, that the policy of Bahr and Brandt that "provided the … political framework for the gas bridge" in the 1960 and

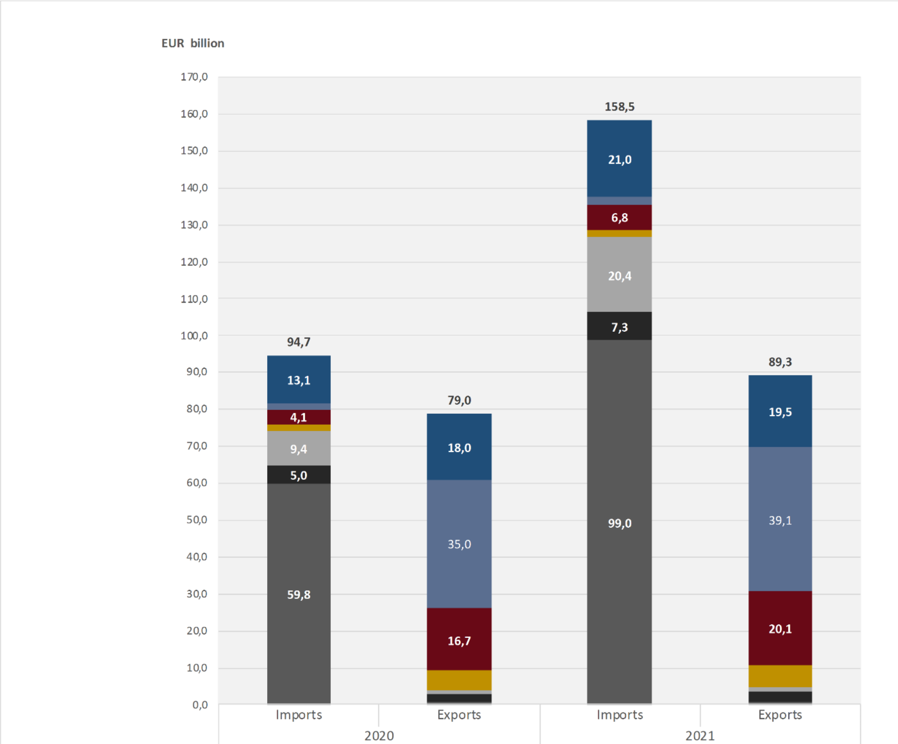
1970 s, "remained [ever since] the foundation of … German policy". "The essence was, that we did not try to solve ideological questions," said Bahr in 2013, in an interview, adding that the *Ostpolitik* was only possible in the context of Richard Nixon's *Détente* – a policy of relaxation towards the Soviet Union (Kundnani, 2014). Yet as time went by, neoliberal views penetrated Europe, and Bahr's concept became tightly coupled to the illusion that trade would induce political change (Kundnani, 2014; Krickovic, 2015; Gustafson 2020, pp.162–166). Indeed, 50 years after the birth of the "rapprochement" idea, Guido Westerwelle – Germany's Minister of Foreign Affairs – emphasized that Bahr's concept was visionary because it "recognized that the goal had to be the transformation of communist rule, not its elimination," and he continued his commemorative speech saying: "Trade brings change. We shouldn't lose sight of the goal of a common economic area from Vancouver to Vladivostok…" (Westerwelle, 2013; Kundnani, 2014).

However, Germany was not alone. Since the 1970s, many West European nations adopted similar "rapprochement" policies towards the Soviet Union and other authoritarian Eastern regimes (Kundnani, 2014; Högselius, 2013, pp. 3 & 125–129; Gustafson 2020, pp. 40–76). Aiming to enter new markets and eager to use the resulting windows of opportunity to expand their businesses, multinational Western corporations had intensified their economic relationships with Eastern nations after the fall of the Iron Curtain even more (Högselius, 2013; Krickovic, 2015; Gustafson, 2020). They have built numerous production sites in Eastern Europe and Asia, got access to new resources and markets, and entered complex legal and economic alliances with Eastern companies. Similarly, Eastern European, and Asian companies established themselves in Western markets. In this context, countries with authoritarian regimes have become important economic partners for Western democracies and significant players in global and/or regional trade (Kundnani, 2014; Groitl, 2021; Mariotti, 2022).

A case in point is offered by China – a nation that developed after the fall of the Iron Curtain into the world's largest trader of goods and its second largest economy after the United States (Groitl, 2021; Kundnani, 2014; Mariotti, 2022). Yet while opening its economy, luring Western trading partners with lucrative projects, and entering an international order dominated by the West, China preserved its ideological stance, continued to violate human rights, expanded its propaganda apparatus, and nipped any democratization attempt in the bud (Groitl, 2021).

Another prominent example – one that is essential for understanding the current energy crisis – is offered by Russia, a nation ranked in 2020 twelfth in exports and fifteenth in imports of goods. As one of the world's largest traders, Russia exported in 2020 goods with a total value of € 291 billion. About one third of its export worth (32.6% or € 94.7 billion) resulted from trade with the EU. In the same year, Russia imported goods for € 210 billion, and its imports from the EU accounted for 37.6% of this value (€ 79 billion) (Eurostat, 2022b, pp. 3–5). As shown in Fig. 2, the EU exported primarily chemicals, machinery, vehicles, and other manufactured goods to Russia, and mostly imported fossil fuels, metals, and other raw materials from Russia (Eurostat, 2022b, pp. 8–9).

Over the past decade, Russia's revenues from exports to the EU always exceeded the country's expenditures for the manufactured goods imported from the EU. Yet




| | 2020 Imports | 2020 Exports | 2021 Imports | 2021 Exports |
|---|---|---|---|---|
| Total | 94,7 | 79,0 | 158,5 | 89,3 |
| Other manufactured goods | 13,1 | 18,0 | 21,0 | 19,5 |
| Machinery & vehicles | 1,6 | 35,0 | 1,9 | 39,1 |
| Chemicals | 4,1 | 16,7 | 6,8 | 20,1 |
| Food | 1,7 | 5,4 | 2,1 | 5,8 |
| Other primary goods | 9,4 | 1,1 | 20,4 | 1,4 |
| Raw materials | 5,0 | 2,3 | 7,3 | 2,6 |
| Energy | 59,8 | 0,6 | 99,0 | 0,8 |

**Fig. 2** EU-27–2020 & 2021: Imports and Exports of Goods by Product Category. (Data Source: Eurostat (2022b))

despite its positive trade balance, Russia's strong reliance on exports of fuels and other primary goods hindered it to develop a competitive manufacturing sector and participate in global value chains (Tajoli, 2022). In contrast, most EU Member States are – irrespective of their income levels – highly involved in European and global value chains and use considerable foreign value added in their exports. This allowed Czechia, Poland, Hungary, and other former satellite states of the Soviet Union to rapidly converge with the EU, while Russia's development lagged behind (Tajoli, 2022). Drawing on Copelans's theory of economic expectations, Tajoli argues that such asymmetries in economic perspectives resulted in increasing Russian-EU tensions, being among the reasons that motivated Russia to opt for a confrontational path (Tajoli, 2022; Copeland, 1996, 2015).

With shares of 7.5% in extra-EU imports (€ 158 billion) and 4.1% in extra-EU exports (€ 89 billion), Russia was in 2021 EU's third largest partner in imports and its fifth largest in exports (Eurostat, 2022b, pp. 6–7; Eurostat 2022d). In the wake of the

Covid pandemic, the EU's trade with Russia dropped in 2020 by 35% in imports (i.e., from € 144.9 billion in 2019 to € 94.7 billion in 2020) and by 10% in exports (i.e., from € 87.8 billion in 2019 to €79 billion in 2020) (Eurostat 2022b, p.9). Yet despite increasing political tensions, EU's trade with Russia recovered within one year to its pre-pandemic levels (see Fig. 2). Following similar patterns, EU's energy imports from Russia dropped in 2020 by almost 40% from their 2019 levels, bottoming at € 59.8 billion, but recovered in 2021 to the € 99 billion mark (Eurostat, 2022b). With a share of 62% in EU's imports, energy was in 2021 by far the most important product category traded between the EU and Russia (see Fig. 2).

Beyond creating new global players and trade dependences, Europe's "rapprochement" attempts also resulted after the fall of the Iron Curtain in complex organizational and juridical entanglements. In his book *Red Gas* Högselius describes, for example, how the success of major German, French, Italian, and Austrian gas utilities in "acquiring stakes in transmission companies that … transit[ed] Russian gas to the West" was limited, because they encountered fierce competition from Gazprom, which eventually became "the main foreign partner in several Central European countries," continuing "its expansion into Western Europe" (Högselius, 2013, p. 210). In the early 1990s, BASF decided to secure its energy supply, by directly importing natural gas from Russia and building a pipeline system parallel to that of Ruhrgas – Germany's largest gas utility. To complete this project, Wintershall – the oil and gas subsidiary of BASF – and Gazprom founded in 1993 Wingas, a 50:50 German-Russian joint venture (Högselius, 2013, p.206; Gustafson 2020, pp. 215–217). Throughout the 1990s, 2000s, and early 2010s Wingas established as major player in the German and European gas markets. During this time, BASF also expanded its gas and oil activities in the Dutch, British, and Danish North Sea, by acquiring in the Dutch company Pennzoil, changing its name in Wintershall Noordzee, and adding the British company Clyde Petroleum to its Noordzee portfolio (Wintershall, 2015). Yet in 2015, BASF transferred its Wingas stakes and 50% of its Wintershall Noordzee stakes to Gazprom, receiving in return minority stakes in West Siberian gas fields (Spiegel, 2015; Wintershall, 2015; Keyzer & Sys, 2021). Through this complex asset-swap, Gazprom became the sole owner of major gas storage facilities in Germany and Austria (including EU's largest storage facility in Rehden) and sole operator of about 7,000 km of critical gas-transport infrastructure in Germany (Wingas, 2017). Over its 50% stake in Wintershall Noordzee, Gazprom got also involved in gas-upstream activities in the North Sea, controlling about 10% of the Dutch production natural gas and oil (Keyzer & Sys, 2021). Beyond having a 20% share in Germany's gas market, Gazprom/Wingas also supplies customers in Belgium, France, the Netherlands, Denmark, Czechia, and Austria with Russian gas (Wingas, 2017). In 2019, BASF sold one third of its stakes in Wintershall DEA – the parent company of Wintershall Noordzee – to LetterOne (a Russian company with strong ties to Gazprom,) increasing the Russian involvement in the Dutch gas market even more (Keyzer & Sys, 2021).

Yet BASF was not the only company that helped Russian corporations to enter the European energy world. Various European-Russian joint-ventures granted Gazprom, Rosatom, Rosneft and other Russian companies access to European gas storage facilities, pipeline systems, refineries, energy markets, joint nuclear projects, Uranium conversion and enrichment services, and nuclear decommissioning projects (Högselius, 2013, pp. 210–211; Keyzer & Sys 2021; Spiegel, 2022b).

“A free international order” would be the prerequisite for “enhancing peace and prosperity,” claimed Westerwelle in his speech about Germany’s “Ostpolitik in the age of globalization,” adding that “close ties” with Russia and new global players like China would be in Europe’s “own vested interest” (2013). Yet, as Groitl remarks, “another form of change through trade has since become reality” – one according to which Russia starts a war of aggression against Ukraine, weaponizing its energy exports to Europe; China sanctions trading partners, research institutions, and parliamentarians who “dare to criticize Beijing’s policies”; and both countries demonstrate their ability to undermine Western economies (Groitl, 2021; Kundnani, 2014; ARD, 2021).

## 4 EU member states at risk: energy dependence and vulnerability/economic interdependence

In the period of hope that succeeded the end of the Cold War, the liberal idea that trade would motivate nations to promote peace and bridge political divides gathered momentum, dominating the political environment, and resulting – as described in the previous section – in mutual dependencies and complex entanglements (Copeland, 2015, p. 1–2). Yet these interdependencies came along with asymmetries in the distribution of trade benefits, mistrust, rivalry, and protectionism, threatening the peace they were supposed to foster (Dent, 2020; Mariotti, 2022). In his detailed historical analysis, Dent unveils that rising populism, escalating protectionism, emerging superpowers, and growing discontent about asymmetric trade relationships and uneven distribution of globalization benefits, which characterize the current political environment, are not peculiar to our century, but rather shared features with the period that preceded World War I (2020). Numerous other contributions also provide evidence that complex economic entanglements can exacerbate both political tensions and security risks (Copeland, 1996, 2015; Högselius, 2013; Kundnani, 2014; Krickovic, 2015; Dent 2020; Gustafson, 2020; Groitl 2021; Mariotti, 2022; Tajoli 2022).

To identify the threats that may arise from the EU’s dependence on Russian fuels and grasp the degree to which supply disruptions may hurt the EU’s economies, one first needs to quantify the imports, break them down by source and Member State, and determine the energy dependency rate for each of the 27 EU economies.

### 4.1 European energy production and imports by source

As we have seen in Fig. 1, oil and petroleum products have the largest share in EU’s energy mix. In 2020, they accounted for 34% of EU’s GAE or 19,919 PJ. Most of this energy (97% or 19,321 PJ) was imported from countries outside the EU (see Figs. 1 and 3).

As an essential raw material for producing transport fuels and chemical products, crude oil is the most traded good in this category, accounting alone for 96% of EU’s

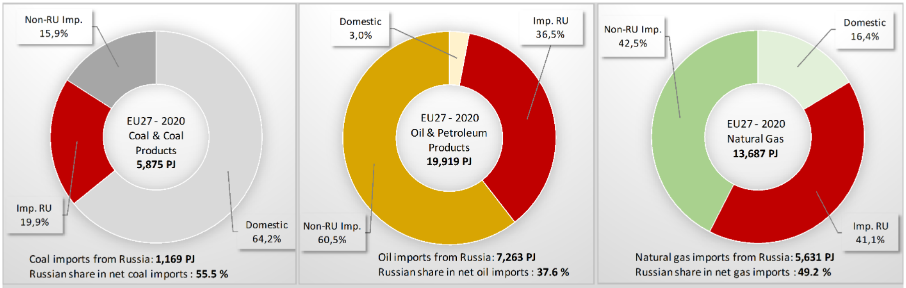



**Fig. 3** EU-27–2020: Domestic production* and extra EU imports of fossil fuels by source. (Data Source: Eurostat (2022a, c, & e) * *Including changes in the stocks of fossil fuel*)

net oil imports (Eurostat, 2022c & e). With 7,264 PJ, a share of 37.6% in EU's net oil imports (Fig. 2; Eurostat, 2022a; McWilliams et al., 2022b), and a trade balance of € 32.1 billion (Eurostat, 2021a), Russia was in 2020 EU's largest trading partner for oil and petroleum products. Alongside with Russia, the United States, Kazakhstan, Nigeria, Norway, and Saudi Arabia were also among EU's important suppliers of oil (Eurostat, 2021a, p.4; 2022 a, p. 6; & 2022 e; McWilliams et al., 2022b).

The second largest energy source in EU's energy mix is natural gas. This versatile commodity is widely used in the generation of electricity and heat, and as raw material in various manufacturing processes. In contrast to coal and oil, natural gas can be used in highly flexible power stations, which play a significant role in leveling the intermittent generation of wind and solar power. Without a breakthrough in large-scale power storage technologies, this commodity is likely to remain essential in achieving European and global decarbonization targets. In 2020, natural gas accounted for 13,687 PJ, or almost one quarter of EU's GAE (see Fig. 1). Only 16% of this energy came from domestic sources, while extra-EU imports of natural gas accounted for the remaining 84% (See Fig. 3). Almost one half of these imports (49.2% or 5,631 PJ) originated in Russia (see Fig. 3). The trade in natural gas with the EU generated in 2020 Russian revenues of € 16.9 billion (Eurostat, 2021a, pp. 5–6). In the same year, Russia was the EU's largest single supplier of natural gas, followed by Norway, and at some distance by Algeria, the United Kingdom, and the United States (Eurostat, 2021a, p.3; McWilliams et al., 2022a). About four fifth of EU's natural gas imports, and more than 90% of its Russian gas imports are transported through pipelines from their countries of origin towards European consumption centers (Leopoldina, 2022, p. 2). Major Russian pipelines transport tremendous amounts of natural gas over thousands of kilometers, often transiting several countries. Indeed, Yamal – the longest Russian gas pipeline – reaches Germany over Belarus and Poland, and can transport up to 33 bcm/a; the Brotherhood and Soyuz pipelines were designed to transport up to 40 bcm/a to Western EU states, crossing Ukraine and several other EU Member States; the two Black Sea pipelines Blue Stream (16 bcm/a) and Turk Stream (31.5 bcm/a) connect Russia to West and Central Europe over Turkey and Bulgaria; and the offshore pipelines Nord Stream 1 & 2 pipelines that directly connect Russia and Germany under the Baltic Sea can transport up to of 55 bcm/a each (due to the Ukraine war, Germany's chancellor Olaf Scholz refused to certify the Nord Stream 2 pipeline)

(Statista, 2022c). Countries located along these pipelines, usually cover significant portions of their gas demand with imports from Russia. Yet beyond granting them easy access to a key resource, these pipelines also increase the countries' dependence on Russian imports. This is precisely why Russian imports of natural gas are more difficult to replace in comparison to oil or coal imports and bear higher risks to harm European economies. Liquefied natural gas – LNG – the alternative to pipeline gas, gained importance over the past two decades, but it was traditionally more expensive than pipeline gas, and covers to date only about one fifth of EU's gas imports (Leopoldina, 2022; McWilliams et al., 2022a). LNG is transported by sea to LNG terminals and distributed from there to consumption sites. Before being used, it undergoes a regasification process. Large LNG terminals usually offer regasification, bunkering, shipment, and/or truck loading services (Howell & Quigley, 2020).

With 5,875 PJ, coal and coal products (mostly hard coal and lignite, but also patent fuel, coke oven coal, brown coal briquettes) accounted in 2020 for 10% of EU's GAE (Fig. 1). Most of this energy (64%) came from domestic energy sources (see Fig. 3). Imports from countries outside the EU covered 36% of EU's coal demand (Eurostat 2022e). With 1,169 PJ, and a trade balance of € 4 billion (The Brussels Times, 2022), and a share of 55.5% in EU's net coal imports (see Fig. 3), Russia was in 2020 the EU's largest single supplier of coal, followed by USA and Australia (Eurostat, 2022a, p.6; McWilliams et al., 2022b). Being a largely available commodity on continental Europe, coal is – despite its high share in extra EU imports – the fossil fuel with the lowest exposure to Russian imports (McWilliams et al., 2022b). In addition, the EU aims to further reduce its coal demand to meet its climate targets.

In 2020, nuclear energy had a share of 13% in EU's energy mix, corresponding to 7,334 PJ (see Fig. 1). This information originates in the official Eurostat statistics and refers to the EU-27 Member States (2022e). Although 95% of the nuclear fuel consumed in the EU comes from countries outside the EU, the Eurostat energy balances do not specify the imports and exports of these fuels, as they do for fossil fuels. This creates the impression that nuclear fuels would be available in the EU, although this is not correct, making it more difficult to assess the EU's dependence on imports of nuclear fuels. In 2020, European utilities loaded their nuclear reactors with fuel (natural uranium, reprocessed uranium, and savings from mixed-oxide (MOX) fuel) equivalent to 13,793 metric tons of natural Uranium (tU). By using MOX fuel one can reduce the demand of natural uranium. Extra EU imports accounted for 95% of EU's uranium demand or 13,124 tU[6] (ESA 2021, p.14). In the same year, Russia supplied European utilities with 2,245 tU, being the EU's second largest partner for imports of natural uranium, after Niger (2,255 tU). Other important partners for the EU's uranium imports were Kazakhstan, Canada, Australia, Namibia, and Uzbekistan (ESA, 2021, p.19). In 2020, Russia and other Commonwealth Independent States (CIS) supplied 43.6% of the EU's uranium demand. In addition to the supply with natural uranium, Rosatom, TENEX, and TVEL – three corporations owned by the Russian

[6] The information about EU's demand of uranium and nuclear fuel services was extracted from the Annual Report 2020 of the Euratom Supply Agency (ESA, 2021). It refers to the EU-28 nations and includes UK's imports of uranium and the conversion and enrichment services commissioned by UK utilities. Since the ESA report contains only aggregated data (i.e., no breakdown by Member States), it is impossible to subtract UK's demand from the EU-28 data set to make it compatible with the Eurostat (2022e) information.

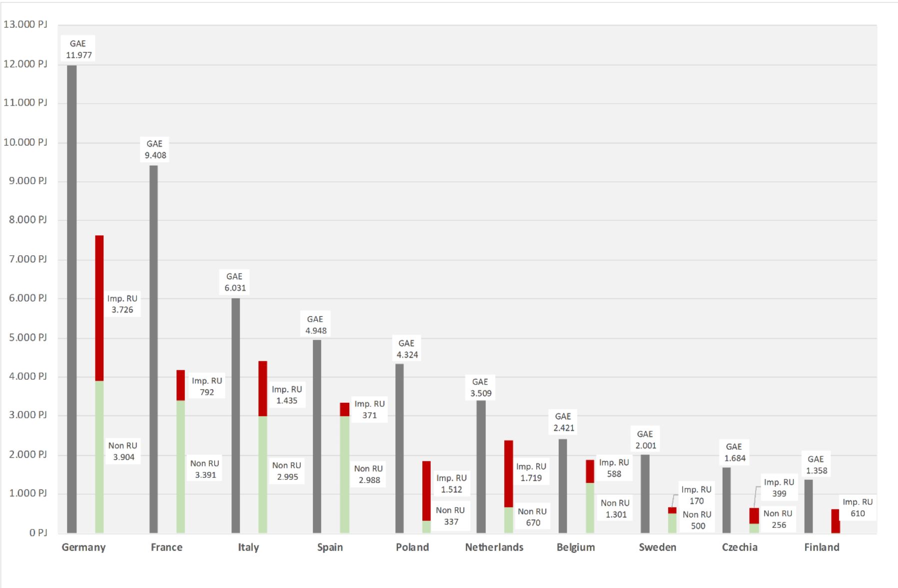



**Fig. 4** EU-27 2020: Member States with the highest GAE and their Russian & non-Russian imports of fossil fuels. (Data Source: Eurostat (2022a, c & e))

state – were among EU's largest providers of uranium conversion and enrichment services (ESA, 2021, pp.21–22). Indeed, Rosatom provided 24% of the conversion services commissioned by EU utilities, while TENEX and TVEL provided 26% of enrichment services commissioned by EU utilities. In addition, 18 nuclear reactors located in Finland, Czechia, Hungary, Slovakia, and Bulgaria are designed to work only with custom-made Russian nuclear fuel elements (Spiegel, 2022b).

### 4.2 How dependent are the EU member states on imports of fossil energy from Russia?

Germany is the EU's largest economy. In 2020, the country generated slightly more than one quarter of EU's gross domestic product (GDP) (Eurostat, 2021b) and accounted with 11,977 PJ for about one fifth of the EU's GAE. In the same year, Germany's net imports of fossil fuels corresponded to 7,630 PJ. Almost one half of these imports (3,726 PJ) originated in Russia (Eurostat, 2022c).

Figure 4 displays the ten largest consumers of energy among the EU Member States – Germany, France, Italy, Spain, Poland, the Netherlands, Belgium, Sweden, Czechia, and Finland – and highlights their Russian and non-Russian energy imports. This figure also visualizes the significant differences between these countries' energy requirements and their dependence on energy imports. For example, Italy – EU's third largest economy – requires only about one half of Germany's energy demand, but imports almost twice as much energy from Russia as France, which is EU's second largest economy. Another case in point is offered by the Netherlands, the nation with the sixth largest energy demand in the EU. Indeed, with 1,719 PJ the Netherlands

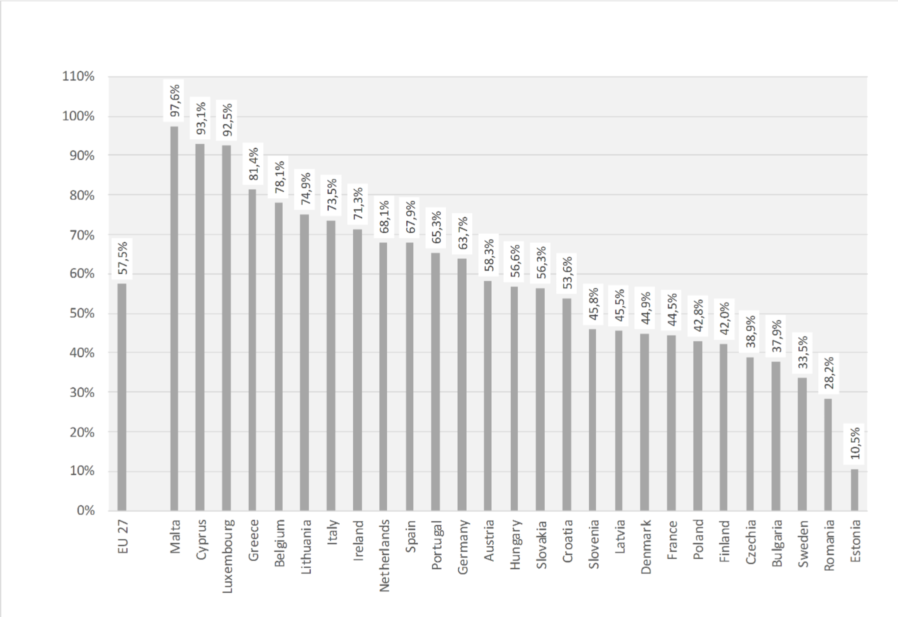



**Fig. 5** EU-27 2020: Energy dependency rate, by Member State. (Data Source: Eurostat (2022a, c & e))

imported the second largest amount of fossil energy from Russia after Germany, and this despite having significant domestic reserves of natural gas.

The *energy dependency rate* is an indicator used to evaluate the degree to which a nation (or region) is dependent on energy imports. To calculate this indicator for an EU Member State, one needs to divide its net energy imports (i.e., imports – exports) by its GAE. The energy dependency rates for the EU and its 27 Member States are presented in Fig. 5.

Similarly, one can calculate a nation's rates of dependency on imports from one or more suppliers of energy, by calculating for each supplier the share of net imports in the country's GAE. Figure 6 shows, for example, the dependency rates on Russian energy imports for the EU and its Member States.

In 2020, the EU imported 57.5% of its overall energy demand from countries outside the EU (see Fig. 5). Imports from Russia accounted in the same year for 24.4% of EU's GAE, or 42.4% of its extra energy imports (see Fig. 6). Among the 27 EU Member States, Lithuania is the nation with the highest dependence on Russian imports. Indeed, Russian imports accounted in 2020 for 96.1% of Lithuania's GAE (see Fig. 6). In addition, Lithuania covered in 2020 about three quarters of its energy demand with imports (see Fig. 5). At the other end of the scale, Cyprus imported only 1.7% of its GAE from Russia (see Fig. 6), and this despite having a significantly higher energy dependency rate than Lithuania (93.1% compared to 74.9%, see Fig. 5).

As shown in Figs. 5 and 6 the degree to which the EU nations are dependent on Russian or non-Russian energy imports can significantly vary from one Member State to another. This is not only valid for small economies like Lithuania or Cyprus,

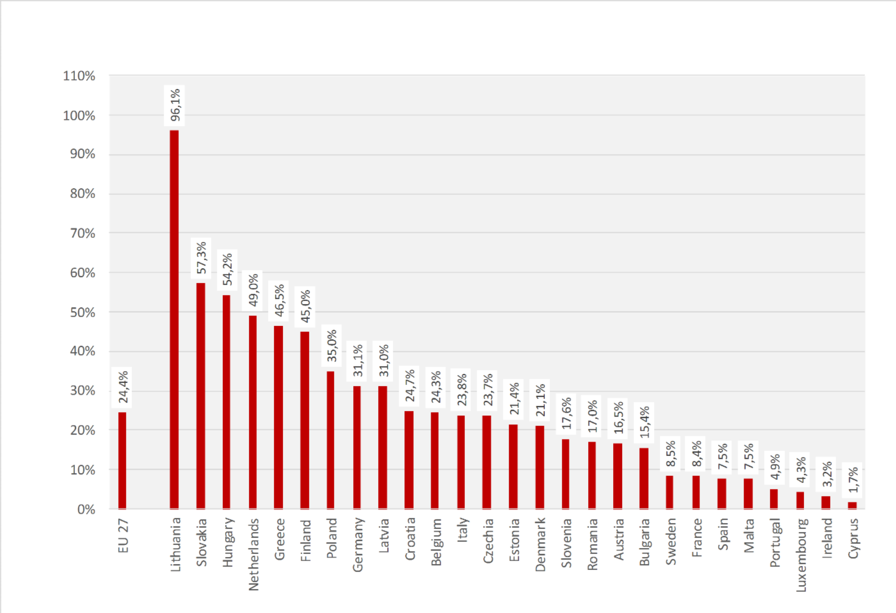



**Fig. 6** EU-27 2020: Shares of fossil fuel imports in GAE, by Member State. (Data Source: Eurostat (2022a, c & e))

but also for EU's largest economies. Indeed, Germany's energy dependency rate in 2020 was 63.7%, while that of France was about 20% lower (see Fig. 5). In the same year, imports from Russia accounted for 31.1% of Germany's GAE, but only 8.4% of France's GAE.

However, as we shall see in the German-Lithuanian case study presented in Sect. 8, the dependency rates are not sufficient to draw reliable conclusions about the degree to which disruptions in the energy supply may hurt the EU's economies.

## 5 Strengthening EU's energy security and regaining its energy sovereignty

The war in Ukraine forced EU Member States to rethink their energy security strategy and join efforts to regain their energy sovereignty. Therefore, the European Commission proposed REPowerEU – a plan aimed at reducing EU's dependence on Russian energy imports (EU, 2022d; EU, 2022h). Since natural gas imports from Russia are strongly dependent on the Russian gas-pipeline system, they have the highest potential to harm European economies and are harder to replace than oil or coal imports. At the beginning of March, the International Energy Agency proposed catalogue of measures aimed at drastically reducing Europe's dependence on Russian gas. All IEA-measures became part of the REPowerEU plan (IEA, 2022; EU, 2022h). The European Commission estimates that EU Member States will be able to regain their independence from Russian energy imports towards the end of this decade. To become independent from Russian gas imports, the EU Member States must rapidly diversify their gas supplies and reduce as far as possible their consumption. Member States can diversify their gas supply by forging new alliances with non-Russian suppliers, establishing new gas transport routes, investing in LNG infrastructure and/or new pipeline connections, and by signing new import contracts. By saving energy (the fastest and least expensive way to reduce consumption) and by substituting natural gas with other fuels or with renewable energies, they can also reduce their gas demand.

To meet their decarbonization targets, the REPowerEU plan recommends Member States to replace natural gas with larger amounts of biomethane and renewable hydrogen production (EU, 2022d). However, as different studies show, it is currently not realistic to produce in the short run sufficient biomethane and renewable hydrogen to significantly reduce a nation's gas requirements (Leopoldina, 2022; Agora Energiewende, 2022a; BDEW, 2022b; IEA, 2022). Given the urgent need to reduce Russian gas imports, these studies recommend to substitute gas with coal in the power sector, and to postpone the transition towards hydrogen economies to the time that follows the phase-out of coal power plants (Leopoldina, 2022; Agora Energiewende, 2022a; BDEW, 2022b; IEA, 2022). For example, Germany initially planned to phase out coal by 2038, but the coalition government of chancellor Scholz pledged to complete the phase-out process by 2030 (Bundesregierung, 2021, p.54). Similarly, Bulgaria, Croatia, Czechia, Poland, Romania, and Slovenia also announced plans to decommission their coal power plants (CREA/Ember, 2022). However, since coal is needed to substitute imports of natural gas from Russia, the coal-based power generation is temporarily increasing, making it even more difficult to meet phase-out deadlines and decarbonization targets.

The REPowerEU plan also includes emergency measures on natural gas storage that require the EU Member States to fill every year their natural gas storage facilities before the winter season (October 1st ) at a minimum level of 90% (EU, 2022d).

With its 'Fit for 55' package of 2021, the European Commission proposed a series of measures aimed at reducing EU's carbon dioxide emissions by 55% from their 1990 levels by 2030 (EU, 2021a). It includes recommendations for reducing the demand of natural gas by 30% or 100 billion cubic meters (bcm,) by boosting energy efficiency, ramping-up renewable energies, improving the European Emission Trading System (ETS,) eliminating grid bottlenecks, sector coupling, and the transition to a hydrogen economy. The Commission estimates that by fully implementing the proposals of the 'Fit for 55'package and the REPowerEU plan, the EU could reduce by 2030 its natural gas demand by 155 bcm (i.e., the volume of natural gas imported from Russia). About two thirds of this reduction could be achieved within one year (EU, 2021a; EU, 2022d).

In a joint statement of March 25th, 2022, the European Commission and the United States confirmed their strategic cooperation in reducing Europe's dependence on Russian energy and their commitment to meeting the goals of the

Paris Agreement and limit the global temperature increase to 1.5°C (UNFCCC, 2015). In this context, the United States will deliver at least 15 bcm additional LNG for the EU market by the end of 2022 and strive to increase these volumes to 50bcm/a (EU, 2022e).

To support Member States in their efforts to substitute Russian gas imports and secure their demand at affordable prices, the European Commission established the EU Energy Platform. This instrument creates a common space for voluntary cooperation in the purchase of gas, LNG, and hydrogen, allowing Member States to improve their bargaining conditions, by pooling their energy demand (EU, 2022h).

In addition to the various mechanisms meant to reduce Europe's dependence on Russian gas, the European Commission added to its REPowerEU plan emergency measures aimed at protecting vulnerable consumers against soaring energy prices. Therefore, the EU complemented its "Energy Price Toolbox" of 2021 (EU, 2021b) with additional provisions allowing Member States to (1) regulate energy prices in exceptional circumstances and redistribute revenues from energy sector profits and emission trading to consumers; and (2) support companies affected by high energy prices in compliance with a temporary 'State Aid Crisis Framework' (EU, 2022d).

The European Commission estimates the additional investment required to regain independence from Russian energy imports at € 210 billion (EU, 2022h). To encourage EU Member States to implement reforms and invest in projects aimed at strengthening their ability to overcome the current energy crisis, the EU enlarged the scope of the Recovery and Resilience Facility (RRF), making additional € 300 billion available for funding REPowerEU plans (EU, 2022h & k). The RRF was initially designed to support Member States in mitigating the social and economic impacts of the Covid pandemic. It became effective in February 2020, making available € 723.8 billion for financing national reforms and investments in line with EU priorities [I.e., reforms and projects in following areas: (1) green transition; (2) digital transformation; (3) sustainable growth, economic cohesion, productivity, and competitiveness; (4) social and territorial cohesion; (5) health, economic, social and institutional resilience; and (6) next generation policies.] (EU, 2022k). In contrast to other incentive mechanisms implemented to steer EU economies in desired directions, the RRF is a performance-oriented financing instrument. To benefit from RRF loans and/or grants, Member States need to conceive Recovery and Resilience Plans (RRPs), commit to timeframes for implementing them, define intermediate milestones for measuring their performance and unlocking funds, and submit their RRPs to the European Commission (EU, 2022k). All reforms and investments must be completed by August 2026. In the current context, EU nations are encouraged to include in their RRPs a REPowerEU chapter (EU, 2022h & k).

## 6 EU sanctions against Russia

In response to the Russian invasion of Ukraine, the European Union adopted to date seven sanction packages. These packages target high profile individuals and entities who supported the invasion of Ukraine and encompass a plethora of economic and financial restrictions on imports, exports, and investments, as well as measures that prevent the Russian state from accessing European capital and financial markets (EU, 2022c, f, g, i &j). The packages 4, 5, and 6 are relevant for the energy sector, because they ban exports of equipment for the Russian energy industry, new investments in the Russian energy sector, as well as imports of coal, oil, and petroleum products from Russia (EU, 2022f, g, i, j, & l; The Brussels Times, 2022). The import embargo on oil and petroleum products (mostly crude oil) is restricted to goods that use maritime transport to enter the EU (i.e., about 90% of all oil imports). Oil imports over the Druzhba (Friendship) pipeline are temporarily exempted from these restrictions (EU, 2022i & j).

With these sanctions, the EU aims to cut Russian energy revenues and avoid energy price increases (Gordon, 2022). Yet only an immediate global embargo would drastically cut Russia's energy revenues (Hausmann et al., 2022). Since a global embargo is not realistic and a delayed embargo would allow Russia to adjust to it, Bruegel analysts proposed instead a punitive tariff on oil and gas imports from Russia [Revenues from gas and oil trade account for about 50% of Russia's federal budget.] (Hausmann et al., 2022). They claim that a European embargo on Russian oil would divert Asian imports from the Gulf countries to Europe resulting in higher prices, allowing China and India to buy discounted Russian oil (Hausmann et al., 2022; Gordon, 2022).

In contrast to Bruegel analysts, Bianco at al. (2022) from the European Council on Foreign Relations consider a phased embargo more effective than a rushed one, arguing that this would help to preserve the EU's unity.

## 7 Policy announcements and their multifaceted implications

Despite their vulnerability to Russian energy imports, EU Member States demonstrated an extraordinary unity in supporting Ukraine's cause. As we have seen in Sects. 5 and 6, these joined efforts materialized in a succession of financial and economic sanctions, and a plethora of rules and regulations aimed at regaining EU's energy independence. The war and the chain of 'act-and-react' dynamics that accompanies it, resulted in 'new rules of the game,' impacted energy markets, economies, and livelihoods, divided the world, and led to new alliances and geopolitical changes. Yet despite this unprecedented and laudable solidarity, it remains highly uncertain whether the changed 'rules of the game' will eventually lead to the desired outcomes (i.e., the end of the war, a secure energy supply, affordable energy prices, and stable economies).

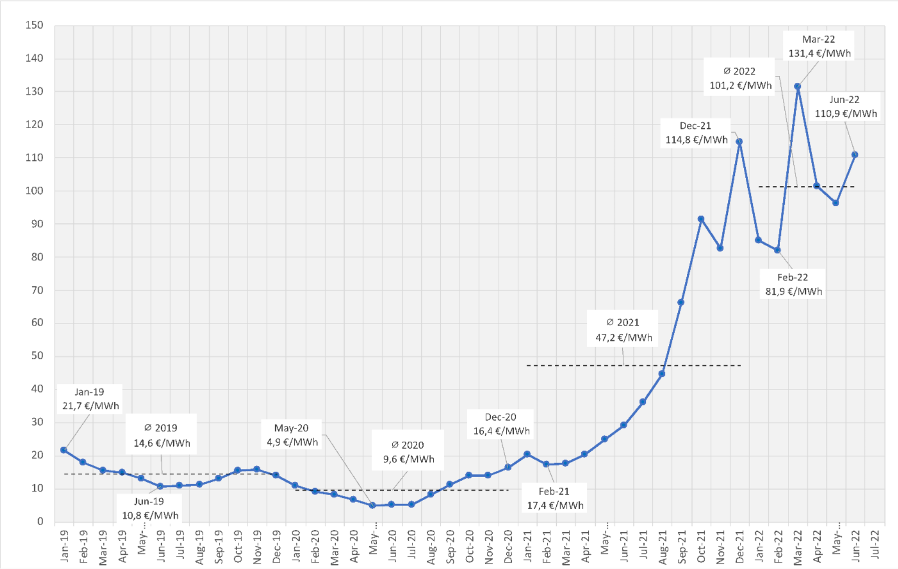



**Fig. 7** Evolution of monthly and yearly TTF average prices for natural gas between 2019 and 2022. (Data Source: Statista (2022d); X-RATES (n.a.))

## 7.1 Soaring energy prices

The current energy crisis has its roots in a series of public policies aimed at mitigating the effects of the Covid pandemic. As we have seen in Sect. 3, the EU's economic output and its energy demand both dropped in 2020, due to the lockdown restrictions imposed in the wake of the pandemic, but they recovered within one year to their pre-pandemic levels. The lockdown restrictions caused severe disruptions in the supply chains, resulting in 2021 in soaring energy prices, and stagflation (IDDRI 2021; BDEW, 2022a & b; Sinn, 2022; GCEE, 2022a & b; Koenen et al., 2022). Indeed, as one can see in Fig. 7, the European wholesale price for pipeline gas (monthly average) at the Title Transfer Facility (TTF) Netherlands varied in 2021 between 17.4 and 114.8 Euro per megawatt-hour (€/MWh) (i.e., gas prices increased between February and December 2021 by 560%).

The war in Ukraine tightened the markets even more, exacerbating the energy crisis (Sinn, 2022). As one can see in Fig. 7, the European gas market seemed to relax at the beginning of 2022 – the monthly average price fell from 114.8 €/MWh in December 2021 to 85.2 €/MWh in January 2022, and 81.9 €/MWh in February 2022. But prices skyrocketed again in response to Russia's invasion in Ukraine, reaching in March a monthly average of 131,4 €/MWh, which is equivalent to a 60% increase within one month. TTF spot and future gas prices temporarily exceeded the monthly average price. For example, on March 7th, the TTF daily spot price reached 212 €/MWh (EU, 2022l). Similarly, the weakly average of the TTF 'month-ahead' gas futures spiked at 227.2 €/MWh in the first week of March (Statista, 2022e). Despite being highly volatile, wholesale prices continued in 2022 their overall upward trend.

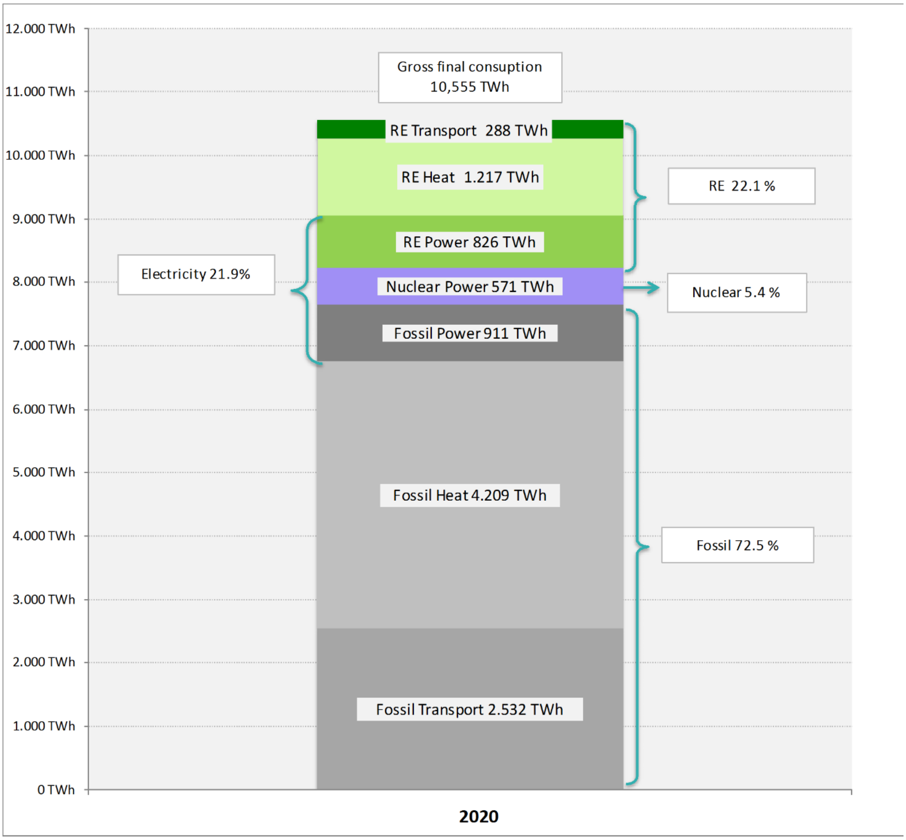



**Fig. 8** EU-27 2020: Renewable (RE), nuclear, and fossil shares in EU's gross final energy consumption by sector. (Data source: Eurostat (2022e, g, & h))

Indeed, their 2022 average (January-June) was more than twice as high as the average price in 2021, and even seven times higher than the 2019 average (see Fig. 7).

The tremendous increase in gas prices experienced in 2022 was partially caused by the fact that Russia curtailed its gas deliveries to Europe as retaliation against EU's sanctions (McWilliams & Zachmann, 2022). Yet prices were also driven by policy announcements and uncertainties related to the future of energy imports from Russia. For example, Germany's refusal to certify the Nord Stream 2 pipeline, Russia's demand to receive payments in rubles, and EU's refusal to meet this demand triggered prices before Russia significantly reduced its supply over its Belarus, Ukraine, and Nord Stream 1 pipeline connections (EU, 2022l).

Oil and coal prices followed similar patterns. For example, the Brent crude oil price rose from 70 €/barrel at the beginning of January 2022 to 92 €/barrel by the end of February, peaking on March 8th at 126 €/barrel (the highest value since the summer 2008,) and remaining for most of the time above 95 €/barrel (EU, 2022l). This high price level was primarily caused by sanctions imposed on Russian oil imports by Western economies (e.g., EU, US, UK) and expectations that the global extraction sites will not ramp-up their production to avoid shortages of oil products on the market.

Similarly, coal spot prices increased between January and February 2022 from 120 €/MWh to 200 €/MWh peaking in the first week of March at 360 €/MWh (the highest coal price ever noted,) varying since between 200 and 300 €/MWh (EU, 2022l). These very high coal prices reflect the increased demand of thermal coal as substitute for natural gas from Russia in the electricity generation.

Compared to pipeline gas, LNG was historically more expensive. However, in 2022 this relationship reversed, and LNG import prices turned lower than TTF wholesale prices. The difference between pipeline and LNG gas prices reached in April and May temporarily 25 €/MWh (EU, 2022l). This unusual phenomenon was caused by infrastructure bottlenecks that limited the distribution of additional LNG imports from EU terminals to EU Member States that needed the commodity (EU, 2022l; McWilliams & Zachmann, 2022; Bloomberg, 2022).

In addition, the overall high price level for fossil fuels translates in similarly skyrocketing electricity prices, and this although about 40% of the generated power is based on renewables that have no marginal costs. The strong correlation between gas and power prices can be explained with the so-called "merit order" mechanism used to establish electricity prices at the wholesale market. Indeed, the power generating capacities offered on the market are called to meet the demand in ascending order of their marginal costs – i.e., first renewable capacities with no marginal costs, and then successively nuclear, coal, oil, and gas capacities, until the supply matches the demand. The power price at the wholesale market corresponds to the most expensive bid accepted to meet the demand (e.g., a gas power plant that has in the current context extremely high marginal costs) (Sturm, 2020, pp.125–126). Beyond placing extreme burdens on power consumers the "merit-order" mechanism generates significant windfall profits in utilities that have high stakes in renewable power.

### 7.2 Burdens on energy consumers and utility companies

Small consumers (households, trades, crafts, services) usually have price adjustments on a yearly basis and will feel the tremendous increase in energy prices starting with October 2022. Large consumers with long-term contracts are – as far as their suppliers cannot interrupt these contracts – in a privileged situation. Yet such long-term contracts that cannot be terminated or adjusted to the current market conditions place tremendous burdens on natural gas suppliers, pushing them on the brink of dissolution. Indeed, Uniper[7] – the German energy giant with the largest share in gas supply contracts – applied in July for government aid. Due to massive cutoffs in Russian gas exports, the company was forced to replace the missing gas volumes on the market, without being able to recover its additional costs from its customers. In July 2022, the German government decided to take a 30% equity stake in and provide a € 15 billion bailout deal for Uniper (WSJ, 2022; CNBC, 2022). In its half-year report

[7] Uniper is the former fossil fuel arm of Eon (the largest German Utility) (WSJ, 2022). After the EON-RWE merger in 2018, the fossil fuel assets of RWE were also integrated in Uniper (Sturm, 2020). Currently Fortum – a Finnish utility - holds 56% of Uniper.

2022, Uniper announced € 12 billion losses from inflated gas prices and additional € 2.7 billion losses in the Nord Stream 2 project (NYT, 2022b). Yet while natural gas utilities are hard hit by the fact that they cannot recover their additional costs from their consumers, electric utilities high stakes in renewable power – benefit from the crisis generating windfall profits.

To protect Uniper and other German natural gas utilities from bankruptcy and prevent Germany's energy market from collapsing, Robert Habeck – Germany's economy minister – announced the introduction of a gas levy, designed to compensate about 90% of the additional costs of gas utilities. Starting with October 1st, all gas consumers must pay for every kilowatt-hour (kWh) they consume 2.419 cents on top of their bills (Reuters, 2022b). Many economists warned that this levy will further increase the inflationary pressure (Reuters, 2022b). The German Economic Institute (Institut der deutschen Wirthschaft - IW) estimates the yearly burden that results from this surcharge for industrial consumers at € 5.7 billion and at € 542 for normal family households (Schaefer & Fischer, 2022). Since these burdens come on the top of the already very high and further increasing power and gas costs, the IW also expects an increase in energy poverty (Schaefer & Fischer, 2022).

To shield vulnerable consumers against the skyrocketing gas, gasoline, diesel, and electricity prices, EU Member States implemented successive release packages. For example, the EU's four largest economies – Germany, France, Italy, and Spain – have spent between September 2021 and June 2022 about € 20 billion to subsidize energy prices and protect low-income households (CREA/Ember, 2022). In this context, researchers from two major European think tanks – Agora Energiewende (Germany) and IDDRI (France) – created a common platform for comparing their countries responses to the current energy crisis and drawing lessons that could help other nations overcome it (Gagnebin et al., 2022).

Simultaneously with introducing of the new gas levy, the German government announced plans to craft an additional relief package to partially compensate the gas levy costs for households. Industrial associations called for measures aimed at avoiding hardship, business migration, and unemployment in energy intensive industries (Reuters, 2022b; Handelsblatt, 2022). In early September, two days after Gazprom announced to indefinitely halt Russian gas supplies over Nord Stream 1, chancellor Scholz presented Germany's new € 65 billion relief package. This package – the third since beginning of the war in Ukraine war – includes a power price break aimed at reducing the price burden on households, trades, crafts, and small industrial consumers, while incentivizing them to consume less, as well as one-time payments for households, increased child support, and incentives to make public transport more attractive. The package also extents the existing tax-breaks for energy intensive industries until the end of 2022 (FAZ, 2022a; NYT, 2022c).

At European level, policymakers work on new set of emergency proposals that include, among other measures, a windfall profit levy on electric utilities. Although the Commission plans to present this package on September 14th, Member States are still split over imposing or not a cap on gas prices (Reuters, 2022d).

### 7.3 Economic outlook

The tight energy markets and the extreme increase in commodity prices bear considerable risks for EU economies. The outcome of the looming energy crisis remains uncertain and strongly dependent on the evolution of the conflict, the imposed trade restrictions, and the supply disruptions caused by Russian retribution measures (i.e., reduced/interrupted gas deliveries). Starting from the assumption that the sanctions imposed on Russia will further stress energy markets causing disruptions in the supply chains and high energy prices, but without resulting in a halt on Russian energy supplies, the German Council of Economic Experts (GCEE) estimated the average GDP growth rate in the Euro area for 2022 and 2022 at 2.9%. Under the same premises the GCEE estimated the inflation rate in the Euro area at 6.2% in 2022 and 2.9% in 2023 (GCEE, 2022a). For Germany, the GCEE expected in comparison growth rates of 1.8% in 2022 and 3.6% in 2023, and inflation rates of 6.1% in 2022 and 3.4% in 2023. Germany's lower than average growth rate in 2022 is rooted in the country's lack of import infrastructure for non-Russian gas imports (i.e., LNG terminals). However, Germany started the construction of two LNG terminals that are expected to start operation by the end of 2022. In addition to this baseline estimate that incorporates the state of the conflict on March 18, 2022, the GCEE experts compared several economic studies, based on different simulation programs and scenario assumptions (GCEE, 2022a & b). These studies quantify the consequences of an intensification of the conflict and a partial stop of energy imports for the Euro area in 2022 relative to the basis scenario with GDP deductions of 1.2–2.2% and an additional inflation of 0.8–2.6%. For Germany, the intensification of the conflict would lead to GDP deductions between 0.9 and 6% and an additional inflation of 1–2%. (GCEE, 2022a & b; Bachmann et al., 2022; ECB 2022; Manager Magazin, 2022). This broad range of possible outcomes is caused by differences in the selected scenarios, showing how dependent the outcomes are on the evolution of the conflict in Ukraine and how difficult it is to predict this evolution.

Using a computable general equilibrium modelling, (CGE) Mahlstein et al. (2022) estimate that an Allied trade embargo on Russia would result for Russia in about 14% losses in real GDP, while Allied countries would lose in comparison only between 0.1% and 1.6% in real GDP. In contrast to the GCEE analysis, Mahlstein et al. also included Allies outside the EU, and non-energy trade in their model.

Several economists claim that the EU should be able to fully ban Russian energy. For example, a group of scholars from Princeton modeled and analyzed the European electricity and gas markets, concluding that that there are several pathways that allow Europe to fully ban Russian gas by October 2022 (Lau et al., 2022). However, this study assumes that additional measures would complement the REPowerEU (i.e., that the existing LNG terminals would function at their gasification capacity, that gas would be temporarily substituted by coal in the generation of electricity, that industries have the flexibility to reduce their demand (Lau et al., 2022).

In a recent study, which has many similarities with the GCEE analysis, experts from the German Ecomomic Institute (IW) claim that most of the existing economic studies underestimate the impacts of a sudden gas supply stop, because they are based on oversimplified modeling approaches that cannot properly capture complex macroeconomic impacts. However, despite the broad range of possible outcomes, IW experts seem to agree that a sudden halt in Russian gas supplies would inevitably lead to a severe recession in Germany and Europe (Koenen et al., 2022).

### 7.4 Investment environment

The REPowerEU plan, the 'Fit for 55'package, and the modified Recovery and Resilience Facility (RRF) provide a favorable frame for investments in renewable energy, LNG, grid interconnectivity, hydrogen, and other sustainable energy projects (EU, 2022 h & k; Allianz, 2022). By modifying the EU taxonomy in February 2022, the European Commission labeled nuclear and gas technologies as sustainable, allowing projects in these realms to compete for funding with renewable energy and infrastructure projects (EU, 2022a). Alongside with the RRF, EU Member States can also use other sources to finance REPowerEU projects – for example, the Connecting Europe Facility, Cohesion Policy Funds, the European Agricultural Fund for Rural Development, or the Innovation Fund. Yet these complex and partially overlapping financing instruments often result in institutional redundancies, competition between the bodies responsible for allocating the funds, and double funding. Despite offering a broad range of funding opportunities, they also make it increasingly difficult for EU Member States to select the best suited funding tools for their projects. In response to the mentioned incentive mechanisms, several Member States announced plans to invest in projects aimed at accelerating the deployment of renewable energies, improving their resilience, and better coping with the current crisis. In addition, the instruments implemented to steer EU economies away from fossil fuels, reduce their vulnerability to Russian imports, and make them more robust, start from the premise that the problems at stake are solvable through political will and financial means. Yet, as we shall see in Sect. 7.7, this approach completely neglects a series of technical barriers to energy transitions that cannot be healed by crafting more rules or injecting more financial means in a system.

### 7.5 Diversifying EU's gas supply

EU's efforts to diversify the gas supply resulted in new contracts with USA, Qatar, Azerbaijan, and other suppliers of LNG, and a more intense use of the existing LNG terminals. During the first quarter 2022, the EU became the largest importer of LNG in the world, before Japan and China (EU, 2022l). The additional LNG volumes compensated to a large extent the reduced pipeline-gas deliveries from Russia (McWilliams & Zachmann, 2022; EU, 2022l). However, almost one fifth of the additional LNG imports originated also in Russia. Indeed, in the first quarter 2022, Russia exported 5.5 bcm of LNG to EU terminals, accounting for 18.3% of EU's LNG imports. It was EU's second largest LNG supplier after the US. LNG supplies from the US accounted for 47% of EU's LNG imports (EU, 2022l). In addition, new LNG contracts closed in very tight markets tend to drive the price level higher, because they replace long-term supply agreements with lower prices (GCEE, 2022b).

The 21 existing European LNG terminals can process yearly 1,900 terawatt-hour (TWh) of liquified natural gas (GIE, 2022; McWilliams et al., 2022a). This capacity slightly exceeds EU's gas imports from Russia. In 2019, the EU imported for example 1,768 TWh (1,612 TWh pipeline gas and 156TWh LNG) from Russia (Leopoldina, 2022). In the same year, European LNG terminals processed 945 TWh (Leopoldina, 2022). Based on 2019 data, the EU's LNG terminals could handle the regasification of additional 955 TWh, which can be used to reduce imports from Russia. To also replace Russian LNG imports EU Member States would need agreements with new partners for 1,111 TWh (955 + 156 TWh). The volumes imported over LNG terminals depend on the evolution of markets and variations in demand. They can significantly differ from one year to another. Compared to 2019, EU's LNG imports in 2021 were lower (i.e., 730 vs. 945 TWh) (McWilliams et al., 2022a; Leopoldina, 2022). Based on 2021 figures, Member States would need agreements with new partners for about 1,300 TWh to fully use the available capacity and replace Russian LNG. Yet even if more than 60% of the Russian gas imports could theoretically be replaced by a more intensive use of the available LNG capacities, the EU's gas-pipeline system was not designed to transport gas from France and Spain – the EU Member States with the largest LNG regasification capacities – to Central or Eastern Europe (McWilliams et al., 2022a; EU, 2022l; GIE, 2022). In addition, the level of interconnection between inner European regions is far from being perfect. For example, the insufficient pipeline connection capacity between France, Spain, and the rest of Europe results in a suboptimal use of the existing LNG terminals (McWilliams & Zachmann, 2022; EU, 2022l; GIE, 2022). A notable example for infrastructural improvements is offered by the former Soviet Union Republics Lithuania, Estonia, and Latvia. Indeed, until recently it was impossible to divert gas volumes from Western and Central European countries for the supply of these Baltic states because they were completely disconnected from the European gas grid. However, this situation changed in April 2020, when the Gas Interconnection Poland-Lithuania (GIPL) was opened (LRT, 2022b & c; McWilliams & Zachmann, 2022).

According to McWilliams & Zachmann (2022) the European LNG terminals reached in the first half of 2022 their maximal operating capacity. The remaining options for additional short-term reductions in Russian gas imports are: (1) to substitute Russian LNG imports with LNG imports from other countries; and (2) to reduce EU's gas consumption. By the end of July, EU Member States agreed to limit their gas demand during the next winter at 85% of their average consumption over the past five years (EU, 2022m). McWilliams & Zachmann (2022) estimate that a 15% demand reduction at EU level should be sufficient to fully compensate Russian pipeline gas, if (1) the EU will continue to fully operate its LNG terminals, (2) the next winter won't become colder than average, and (3) the levels in the European gas storage facilities will not drop under 20%. However, considering their degree of dependence on Russian imports and the existing interconnection bottlenecks in the European pipeline system, some countries like Bulgaria, Hungary, Serbia need to reduce their gas demand up to 50%, while others like Spain, Portugal, and France could overcome the winter without reducing their consumption at all (McWilliams & Zachmann, 2022). This shows how important it is to eliminate grid bottlenecks and speed-up the construction of new LNG terminals. Germany, Italy, France, Poland, Greece, and the Netherlands announced plans to build new LNG terminals or enlarge the regasification capacity of existing ones. Additional 1,100 TWh/year are expected to come online by 2030 (GIE, 2022). Under normal circumstances stationary LNG projects need 3 to 5 years to be completed, while floating LNG terminals require therefore between 1½ and 2 years (GIE, 2022). However, Member States could reduce the required time amount for the construction of LNG terminals by speeding-up their permitting procedures. For example, Germany – a country that had no LNG terminal when Russia invaded Ukraine – started in the wake of the war three LNG projects: two floating LNG units in Brunsbüttel and Wilhelmshafen, and a stationary LNG terminal in Stade (GIE, 2022). The LNG terminals in Brunsbüttel and Wilhelmshafen have a total capacity of 12.5 bcm, corresponding to about 13% of Germany's gas demand. The LNG terminal in Stade with a gasification capacity of 13.3 bcm and is expected to start operation in 2026 (HEH, 2022). By speeding up the permitting procedures and construction works, and simultaneously contracting the required LNG volumes, the two floating LNG units are expected to start operation by the end of 2022 – i.e., in less than one year since these projects started (Reuters, 2022c). Similarly, Poland speeds-up the works at the LNG terminal in Gdańsk (GIE, 2022).

In addition, several Member States started projects to improve their interconnectivity to the European grid. For example, the final works at the Poland – Slovakia interconnector were completed in June 2022, the Greece – Bulgaria connection entered in operation in July, the Baltic Pipe that connects Norway to Poland will become operational in October 2022 (McWilliams & Zachmann, 2022). In the wake of the Ukraine war, Spain, Portugal, and Germany tried to relaunch the MidCat pipeline project that was cancelled in 2019 due to high costs and lack of utility. Yet although this pipeline could help to transport LNG from Spain over France to North and Central European countries, France continues to oppose it, arguing that the connection would be too expensive (Messad, 2022).

### 7.6 Accelerating the transition to low carbon technologies

In response to the current energy crisis, 19 EU Member States announced more ambitious plans to ramp-up renewable energies and speed-up their transition towards low carbon technologies (CREA/Ember, 2022). Most of the projects are aimed at increasing the generation of renewable power. Indeed, 12 of 19 EU Member States aim to increase the renewable energy share in their power generation above 50%. Three EU Member States – Austria, Denmark, and Portugal – aim to generate by 2030 100% of their power using renewable energy sources (CREA/Ember, 2022). In addition, several other countries significantly increased their initial renewable power targets for 2030 (e.g., Netherlands > 95%, Germany 80%, Spain > 75%, Italy 70%, Ireland 70%, Greece 70%, Sweden 70%, Romania 63%). All announced projects are expected to lead by 2030 to an EU-wide renewable energy share in the gross electricity generation of 63%, compared to previous commitments of 55% (CREA/Ember, 2022; EU, 2022d & h).

EU's decision to label nuclear and gas technologies as sustainable, resulted in a revival of nuclear power (EU, 2022a). While France decided, for example, to build 14 new nuclear reactors with a total capacity of 25GW, Belgium expanded the lifespan of its nuclear power plants by 10 years starting with 2025, Greece and Bulgaria plan a nuclear facility that supplies both countries with energy, and Hungary plans to expand its nuclear capacity, although the technology was developed by Rosatom and might be subjected to sanctions (CREA/Ember, 2022).

Some National Energy and Climate Plans (NECPs) as for example that of Poland and Belgium include large natural gas projects. However, given EU's extreme dependence on Russian gas and the extremely tight gas markets, these countries will probably review these plans and renounce large gas expansion projects (CREA/Ember, 2022). In addition, several Member States announced more ambitious plans for reducing their dependence on fossil fuels and complemented them with timelines for the phase-out of their coal power plants (e.g., Hungary 2025; Romania 2032; Croatia, Czechia, and Slovenia 2033; Germany 2030; Bulgaria 2038–2040; Poland 2049) (CREA/Ember, 2022). Among these countries Germany declared, for example, that it will phase out its coal power plants in 2030 (i.e., 8 years earlier than initially planned). However, as briefly addressed in Sect. 5, some of these Member States increased in the wake of war their coal-based power generation to cope with the significant reductions in Russian gas supplies and fill-up their gas storage facilities before the next winter season, and might need to revise their coal phase-out plans (Agora Energiewende, 2022b; Leopoldina 2022).

As mentioned at the beginning of this section, most of the projects pursued by EU Member States are in the electricity sector and aim to increase the generation of renewable power. Yet electricity accounts for less than one quarter of EU's gross final energy consumption (see Fig. 8).

The share of renewable energy in EU's gross electricity consumption steadily increased over the past decade, reaching 37.5% in 2020 (Eurostat, 2022g). However, the deployment of renewable energy in the sectors heating/cooling and transport lagged with 22.4% and 10.2% respectively, and the share of renewables in EU's gross energy consumption was only 22.1% (Eurostat, 2022g). This means that even if the EU went 100% renewable in the power sector, its gross energy consumption would still depend to 64% on fossil energy if Member States do not focus more on advancing low carbon technologies for the sectors heating/cooling and transport (see Fig. 8).

Four Member States also announced projects in the heating/cooling and transport sectors, and/or investments in improving the power-storage and/or -transport infrastructures (CREA/Ember, 2022). For example, Denmark plans to switch by 2028 400,000 households to district heating or heat pumps; Ireland aims to increase by 2030 the efficiency standards for 500,000 households; Germany bans by 2025 fossil heating in new buildings; France eliminated subsidies for gas heating in residential areas promoting instead "virtuous" (green) heating and introduced a €150 million incentive plan to encourage companies and municipalities to switch to renewable heating. All four countries also introduced measures to decarbonize the transport sector. In addition, Denmark aims to install by 2030 up to 6 GW in green hydrogen facilities. At EU level, the REPowerEU encourages the deployment of heat pumps, aiming to implement within the next 5 years 10 million new units, and includes €3 billion in funds for hydrogen applications in manufacturing processes and innovative electrification. However, renewable projects in the sectors heating/cooling and transport are rather rare compared to those in the electricity sector.

### 7.7 Barriers to transition

Given that their hydro and biomass potentials are almost exhausted, EU Member States must expand their renewable power generation mainly in wind and solar. This is clearly reflected in the projects pursued by EU Member States. Indeed, the EU Member States are expected to generate by 2025 additional 58TWh by installing new rooftop solar facilities; Germany plans to increase its photovoltaic capacity from 54 to 200 GW by 2030; Greece, Denmark, France, and Bulgaria also plan large scale solar projects; Germany, Denmark, Belgium, and the Netherlands plan install 150 GW offshore wind in the North Sea by 2050; etc. (CREA/Ember, 2022). Yet solar and wind have highly intermittent patterns and there is no affordable technology in place able to store electricity at the required scale to level them (Sturm, 2020). This is precisely why the intensive deployment of renewable energies comes along with a series of barriers to transition that cannot be solved by crafting more sophisticated rules and incentive mechanisms.

One way to think about intermittency is that of comparing the yearly electricity generation from installing one megawatt (MW) in conventional and renewable power facilities. While every MW installed can generate within one year about 8,000 megawatt-hours (MWh) in the case of conventional power, it can generate only between 1,500 and 2,500 MWh in the case of wind, and between 800 and 1,000 MWh in the case solar power. The amount of power generated in wind and solar strongly depends on the location of wind and solar parks. Indeed, wind parks located offshore or in windy coastal areas generate more power per installed MW than landlocked ones. Similarly, solar parks located in countries with strong sun incidence like Spain or Italy produce more power per MW installed the ones located in Germany. To replace the amount of power currently generated in their fossil power plants, EU Member States must thus install up to 10 times more capacity in solar power, or about 4 times more capacity in wind power (Sturm, 2020). Yet even if they generated the same amount of power over one year, this does not mean that Member States could always match their supply and demand. For example, on sunny and windy holidays, when demand is low, the renewable generation easily exceeds the power demand, but it remains below the demand curve on cold, windless nights with high consumption patterns. Despite being quite stable over long periods of time, the generation of hydropower has significant seasonal fluctuations, because it depends on the levels of water in the hydroelectric reservoirs, which are low in the winter, begin to increase in late spring when the snow melts, and high in the summer.

The following example from practice may help in understanding the relevance of the intermittency problem in energy transitions. January 24th, 2017 was a cold, dark, and windless day in Germany. At 7:00 am the country's power demand was 69.7 GW. The renewable capacity installed in Germany at the beginning of 2017 slightly exceeded 100 GW and would have been sufficient to meet the country's demand that morning, but the wind was not blowing, the sun was not shining, and the hydropower worked only at 25% of its capacity. From the total of 87.4 GW installed in wind and solar only 0.8 GW were available for meeting the country's demand. Overall Germany generated 8.4 GW of renewable power [I.e., 0.8 GW of 45.92 GW installed in wind parks, 0 GW of 41.43 GW installed in solar facilities, 1.3 GW of 5.6 GW installed in hydropower stations, and 6.3 GW of 7.07 installed in biomass power plants.] and complemented the missing 61.3 GW with hard coal, lignite, natural gas, and nuclear generation (Sturm, 2020, p. 137). Such periods of low renewable energy output occur each winter and can persist 10 days in a row. For example, renewable energies generated between January 16 and 27, 2017 less than a quarter of Germany's power demand. To meet the country's demand in this period, German utilities generated 12,679 GWh of conventional power. Since this problem doesn't disappear by accelerating the deployment of renewables, Germany would require a power storage volume of about 13,000 GWh to overcome the winter without conventional power (Sturm, 2020, p.142).

The least expensive and most effective way to store large amounts of electricity is to transform excess power into potential energy by pumping water uphill into reservoirs that can provide hydroelectric power on demand. Large pump-storage facilities can store approximately one GWh, which means that Germany would need about 13,000 such facilities to overcome the winter. Yet there are currently only 36 pump-storage facilities in Germany (Sturm, 2020, p.142). In addition, the construction of new large reservoirs rises concerns about local environmental impacts and tends to encounter strong opposition from citizens, communities, and environmental groups. Massive protests hindered, for example, the realization of the 1.4 GWh pump-storage project in Atdorf that would have been the largest European pump-storage facility (Sturm, 2020, p.58). In comparison, the 68 large-scale stationary battery systems deployed in Germany by the end of 2019 could only store 0.62 GWh (Figgener et al., 2020). Given the difference in the order of magnitude such batteries (mostly lithium-ion batteries) may help leveling short power intermittencies up to 420 MW, but do not offer viable solutions for overcoming longer periods of low renewable energy generation (Figgener et al., 2020).

Periods in which the renewable sources are abundant and generate more power than needed to meet the demand are also problematic. In Germany, such situations resulted for example in forced power exports to adjacent countries and negative electricity prices (i.e., users ended up in receiving payments for consuming more electricity than contracted). Even if it were possible to craft rules that would hinder forced exports and negative prices, the more wind and solar power are fed into the grid, the more challenging and costly it becomes to balance it (Sturm, 2017; Sturm 2020, pp. 143–147). To benefit from low and even negative power prices in periods with high renewable power generation, industrial sites that need heat for their manufacturing processes installed "power-to-heat" aggregates (i.e., electric boilers). Such aggregates can reduce grid imbalances by converting excess power into heat. However, the use of 'power-to-heat" technologies will probably maintain their "niche" character because they require a heat-sink in their proximity and cannot be used in periods in which electricity prices are high (Sturm, 2020, p.143).

"Power-to-gas" technologies can also help to level wind and solar intermittencies. They convert in an electrolysis process excess power into hydrogen – a storable product – that can be then used to fuel cars and manufacturing processes, or to produce synthetic methane. While the exhaust from burning fossil fuels contains chemical compounds that harm the environment or induce climate change (e.g., oxides of nitrogen, sulphur, and carbon,) the combustion of hydrogen results in water vapor that can be released into the atmosphere without any concerns. However, the energy consumed to produce hydrogen in an electrolysis process is higher than the energy released by burning the hydrogen produced. Thus, it makes little sense to use conventional fuels to produce the power required for the hydrogen production. Such processes can make sense only if excess green power is available at very low or even negative costs (i.e., in periods in which solar and wind power are abundant and the generation of power exceeds the demand). It is furthermore not clear whether the production and storage of hydrogen can be operated in a highly intermittent regime. Power-to-gas technologies have been mostly tested in small-scale pilot units. However, since July 2021 Shell operates a 10 MW power-to-gas unit in Wesseling, Germany – currently the largest electrolysis plant in Europe. In a second phase, Shell plans to scale-up the electrolysis capacity to 100 MW (Energate, 2021). Vattenfall, Shell, Mitsubishi Heavy Industries, and Wärme Hamburg pursue another 100 MW 'green' hydrogen project that is expected to be completed in 2025 (S&P, 2021). Thus, hydrogen facilities seem to gather momentum. However, the technology is currently fraught with subsidies. In addition, the large-scale use of hydrogen in modern economies also require sound sector coupling concepts that allow the optimal use of excess renewable power in decarbonizing the sectors heating/cooling and transport, readiness for replacing conventional fuels with hydrogen in industrial processes, use massive investments in hydrogen infrastructure and logistics, and innovations in all sectors of economic activity. Thus, there is it still a long way to go until 'green' hydrogen storage can really help overcome German winters. To assume that Germany would be able substitute in 2030 its entire demand of natural gas with hydrogen, is furthermore unrealistic, as Veronika Grimm – one of the GCEE experts – said in a recent interview (Manager Magazin, 2022). This means that hydrogen may play a role in substituting fossil fuels in the future, but it is irrelevant for overcoming supply shortages in the short run (Leopoldina, 2022; Agora Energiewende, 2022b; Manager Magazin, 2022).

Wind and solar intermittencies and the lack of affordable power-storage are not the only problems in energy transitions. Another major barrier to EU's energy transition is that its power grids were not conceived for the long-distance transmission of power, because power plants were located near consumption centers. The transport of power from wind offshore platforms and windy onshore regions to consumption centers requires massive investments in high voltage power lines. Yet such large infrastructure projects tend to encounter massive opposition from people who do not want to live in the proximity of high voltage power lines, and from property owners, who refuse to grant utilities rights of way over their land (Sturm, 2020, pp.147–149).

## 8 Comparative vulnerability assessment of two EU member states

The indicators presented in Sect. 4.2 offer a good overview about the degree of dependence on energy imports of the 27 EU Member States but are alone insufficient to draw reliable conclusions about the degree to which bans on Russian energy imports may hurt European economies. Indeed, using the dependency rates shown in Fig. 5, one might conclude, for example, that Lithuania that imports 96.1% of its energy from Russia is at a much higher risk to be harmed by sanctions against Russian energy imports than Germany, which imports only 31.1% of its energy from Russia. Yet is this indeed so?

To find the answer to this question one needs to complement the two countries' dependency rates on Russian imports with information about their economies, the absolute amount of energy they need to replace, their access to energy markets and alternative energy sources, their bargaining power, their resilience against disruptions in energy supply, and the pace at which countries are able to substitute Russian imports, diversify their fuel imports, adjust and enlarge their existing infrastructure to challenges resulted from disruptions in the fuel supply.

### 8.1 Germany vs. Lithuania – Economy and energy

In 2020, Germany's GDP was 68 times larger than the Lithuanian one in absolute terms [I.e, € 3,367.6 billion compared to only € 49.5 billion.] and 2.3 times larger in per capita units [I.e., 40,490 €/capita compared to only 17,710 €/capita.], but despite these significant differences in order of magnitude and wealth, the economic structure of both nations are quite similar (Eurostat, 2022f). Indeed, in both countries the services sector is the largest, generating around three fifth of their GDP [I.e., services accounted in 2020 for 63.3% of Germany's GDP and 61.6% of Lithuania's GDP.], being followed by the industry sector that accounts for about one quarter of the national GDP [I.e, for 26.5% of Germany's GDP and 25% of Lithuania's GDP.], and the agriculture sector that contributes with less than 5% to the national GDP (see Fig. 9).

In addition, the exports of manufactured products significantly contribute in terms of value added to the GDP of Germany and Lithuania (Rudzkis & Titova, 2006). Irrespective of the huge difference between the two countries' export worth in absolute terms, the differences significantly diminish in per capita terms placing Germany 12th and Lithuania 19th in the global ranking (OEC, 2022a & b).

Table 1 compares Germany and Lithuania in 2020 in terms of their (1) energy requirements (GAE), (2) net energy imports, and (3) imports from Russia, highlighting the contribution of fossil energy (oil, natural gas, and coal) in these categories.

In 2020, fossil energy accounted for roughly three quarters of Germany's requirements (i.e., 9,210 of 11,977 PJ) and two thirds of Lithuania's gross energy requirements (I.e., 217 of 327 PJ). As we have seen in Sect. 4.2, both countries rely to a large extent on Russian and non-Russian imports of fossil energy to meet these demand (Figs. 5 and 6; Table 1).

To support the Ukrainian cause, EU policymakers strive to regain as fast as possible their independence from Russian energy imports. Therefore, they need to diversify in the short run their import sources and accelerate in the long run their transition towards low carbon technologies. Based on the 2020 data presented in Table 1, the diversification target translates in finding short term replacements for 1,484 PJ of oil, 1,841 PJ of natural gas, and 401 PJ of coal in Germany's case (or 31.1% of Germany's GAE), and for 128 PJ of oil, 83 PJ of natural gas, and 5PJ of coal in Lithuania's case (or 96.1% of its GAE). The reduced economic activity during the Covid pandemic

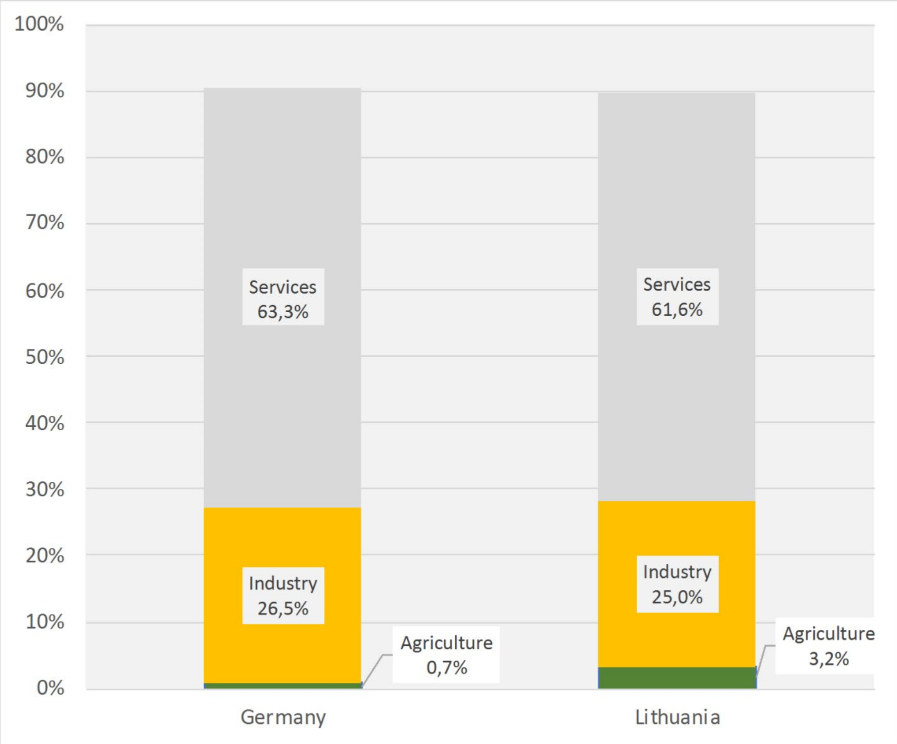



**Fig. 9** Germany vs. Lithuania: Distribution of the GDP across economic sectors. (Data Source: Statista (2022a & b))

**Table 1** 2020: Germany vs. Lithuania – GAE, net energy imports, and energy imports from Russia, by source. (Data Source: Eurostat (2022c & e))

| | Germany | | | Lithuania | | |
|---|---|---|---|---|---|---|
| | **GAE** | **Net Imp.** | **RU Imp.** | **GAE** | **Net Imp.** | **RU Imp.** |
| Total | 11,977 PJ | 7,630 PJ | 3,726 PJ | 327 PJ | 245 PJ | 314 PJ |
| Oil & oil products | 4,220 PJ | 4,074 PJ | 1,484 PJ | 128 PJ | 132 PJ | 260 PJ |
| Natural gas | 3,123 PJ | 2,783 PJ | 1,841 PJ | 83 PJ | 82 PJ | 42 PJ |
| Coal & coal products | 1,867 PJ | 824 PJ | 401 PJ | 6 PJ | 5 PJ | 4 PJ |
| Renewable energies | 1,965 PJ | | | 69 PJ | | |
| Nuclear heat | 694 PJ | | | | | |
| Others | 107 PJ | | | 41 PJ | | |

resulted in lower energy requirements in 2020. That is why, the real replacement requirements are roughly 10% above the 2020 values presented in Table 1.

Countries with high energy demand and strong economies like Germany have in general significantly more bargaining power compared to smaller and less wealthy countries like Lithuania. Not only that they are more attractive as trade partners for long-term energy contracts, due to their high energy demand, but they also have more financial means to overbid their competitors and honor their import contracts. However, such competitive advantages may lose their relevance in the current context. Indeed, when large consumers make efforts to steer their economies away from fossil fuels, they become less attractive as partners for long-term energy supply contracts. Moreover, as discussed in Sect. 7.1, the global energy demand increased steeply after lifting the lockdown restrictions related to the covid-pandemic, resulting in tight energy markets and high energy prices. In addition, the West's decisiveness to ban Russian energy imports, eliminates a major energy supplier, making the markets tighter, and exacerbating the looming energy crisis even more. When energy markets become as tight as they currently are, it is easier to replace smaller amounts of energy.

### 8.2 Germany vs. Lithuania – vulnerability to russian coal imports

Given the small share of coal that needs to be replaced in their countries' GAE, the relative abundance of coal on the globe, and the well-functioning coal market, neither Germany nor Lithuania is likely to encounter major problems in negotiating contracts with other coal suppliers. Germany aims to fully replace its Russian coal before the next heating period. According to the German Association of German Coal Importers (Verein der Kohlenimporteure) imports from USA, Columbia and South Africa could replace Russian imports within few months (NTV, 2022). To date, Germany was able to reduce the Russian share in the nation's coal import from 50 to 8% (BMWK, 2022c). Lithuania's coal imports from Russia are in absolute terms very low (5PJ in 2020) and lost even more significance after October 2021, when Vilnius placed a ban on the use of coal briskets for heating (LRT, 2021a). Thus, Lithuania should be able to either completely replace its remaining coal demand with imports from neighboring Poland, or even substitute it with other energy sources. Vilnius encourages, for example, its inhabitants to replace coal and peat briquets with biomass (LRT, 2021a).

### 8.3 Germany vs. Lithuania – vulnerability to russian oil imports

Oil – the fossil resource with the largest contribution in the energy mix of Germany and Lithuania – is more difficult to replace than coal. Indeed, in Lithuania's case, oil imports are the major driver for the country's strong reliance on Russian imports. As shown in Table 1, the country's oil imports from Russia are about twice as high as its oil demand. The explanation for this unusual fuel balance lies in the fact that Lithuania is a large exporter of oil products [The country was in 2020 the 36th largest exporter of refined petroleum in the world (OEC, 2022b]. Thus, Lithuania uses the crude oil imported from Russia in the Orlen Lietuva refinery, and exports refined petroleum products from this facility to Ukraine, Latvia, USA, Estonia, and Netherlands (OEC, 2022b). Since it has been conceived for Russian oil, which has in comparison to oil from other regions a higher sulphur content, the Lithuanian refinery would require adjustments before using oil from other sources, said Michael Rudniki, the CEO of Orlen Lietuva, in an interview in 2021 (LRT, 2022a). In 2022, Orlen Lietuva started a € 641 million project aimed at adapting the Lithuanian facility for the use of non-Russian oil qualities (LRT, 2022a). At the beginning of March, the company also contracted oil from Saudi Aramco, declaring that it would be prepared to completely ban Russian oil imports (BBC, 2022). Lithuania's president, Gitanas Nausėda said in an BBC interview on March 16th that his country is willing to completely ban gas and oil imports from Russia (BBC, 2022). In April the Lithuanian refinery completely abandoned crude oil imports from Russia (LRT, 2022c; Orlen Lietuva, 2022).

Germany also worked hard on reducing its dependence on Russian oil. By the end of May 2022, when the EU Member States agreed on cutting their maritime imports of Russian oil, Germany succeeded to reduce its dependency rate on Russian oil imports by about two thirds (i.e., from 35 to 12% of its total oil demand) (EU, 2022i & j; ZDF, 2022; BMWK 2022a, b, & c). The country still imports about 12% of its oil demand over the Druzhba (or Friendship) pipeline system that directly connects Russian extraction fields to the German refineries PCK and Leuna (ZDF, 2022; RBB, 2022). Since Russian pipeline imports are – until the European Council decides otherwise – exempted from the embargo, Germany doesn't expect shortages related to EU's oil sanctions (EU, 2022i, (16); ZDF, 2022). Irrespective of EU's exemption for pipeline imports, Germany strives to fully ban its Russian oil imports by the end of this year. Like the Orlen Lietuva facility in Lithuania, the German refinery PCK was designed for Russian crude oil. To avoid plant adjustments, the country tries to import crude oil from regions that extract oil with similar properties to the Russian oil (E.g., South America, Iran, or Irak) (ZDF, 2022). Yet even if Germany will be able to close new import agreements and solve the transport logistics on time, the majority owner of the PCK refinery remains Rosneft, a company owned by the Russian state. As briefly addressed in Sect. 1, Germany's Federal Antitrust Authority approved the Rosneft–Shell deal, only three days before the Russian invasion in Ukraine, allowing Rosneft to increase its stake in PCK from 54.17 to 91.67% (Spiegel, 2022a; RBB, 2022). However, to be completed, the transaction requires the approval of Robert Habeck – Germany's economy minister (NYT, 2022a). Habeck, who has no intention to approve the transaction, works instead on finding alternative supply solutions for PCK and creating the legal framework for taking control over Rosneft. Such imports could reach the refinery over the ports Rostock (Germany) and Gdansk (Poland), but Rosneft has no interest in banning Russian oil, and Poland refuses to ship oil for a Russian company (NYT, 2022a). Thus, the situation remains dire.

### 8.4 Germany vs. Lithuania – vulnerability to imports of natural gas from Russia

As we can see in Table 1, natural gas represents the second largest source of energy in the energy mix of Germany and Lithuania, accounting in both countries for roughly one quarter of their gross energy demand. To meet their gas requirements, Germany and Lithuania relied in 2020 to 89% and 99% respectively on imports. Although Germany's gas imports from Russia are in absolute terms significantly higher that Lithuania's (1,867 PJ vs. 42 PJ,) both countries covered between one half and three fifth of their gas demand with Russian imports (i.e., Germany 59%, and Lithuania 51%). Yet despite having similar dependency rates on Russian gas imports, Germany and Lithuania adopted – given their different histories – fundamentally different strategies in securing their energy supply.

Lithuania – a country of only 2.8 million people – had to fight hard to become more independent from Russia, being severely punished by its powerful neighbor for every single step it took in this direction. This forced Lithuanians to be alert to potential threats from Russia. To secure its natural gas demand and reduce its dependence on Russian energy imports, Lithuania decided in 2012 to build an LNG terminal and started to forge alliances with the Norwegian company Statoil and other potential gas suppliers. The floating LNG terminal, symbolically named "Independence," arrived in the Lithuanian port Klaipėda in 2014, and became operational in 2015 (LRT, 2015a; LRT 2021b). The terminal can completely cover Lithuania's natural gas demand, and about 90% of the demand of its neighboring countries Estonia and Latvia (LRT, 2015b). Since LNG was more expensive than pipeline gas and Russia significantly dropped its gas prices even before the terminal became operational, there was no need to operate the terminal at full capacity. However, after lifting the lockdown sanctions, gas markets became tight and Lithuania increased its maritime imports, covering in 2021 about 65% of its demand with LNG (LRT, 2021b). Lithuania's efforts to increase the energy independence in the Baltic region did not stop with the Independence vessel sailing into the port of Klaipėda. In 2015, Lithuania started a joint pipeline project with neighboring Poland. The Gas Interconnection Poland-Lithuania (GIPL) was completed just in time to help Poland overcoming the supply halt imposed on it by Gazprom. Indeed, on April 27th, 2022, Gazprom stopped to honor its gas supply contracts with Poland and Bulgaria, as retribution for their refusal to use the Russian Ruble as payment currency – a sanction meant also as warning for Germany, as largest importer of Russian gas, and for all other EU Member States (CNN, 2022). Yet beyond being a "lifesaver" for Poland, the project increases the energy security in the Baltic region, by connecting it to the European gas grid (LRT, 2022b & c). After opening the Baltic Pipe (a pipeline connecting Norway and Poland that is currently under construction and will be opened in October 2022,) the GIPL connection can be used in reversed direction to fully supply Lithuania and the other Baltic states with Norwegian gas (LRT, 2022b). Since April 2022, Lithuania completely stopped its Russian gas imports, becoming the first EU Member State that bans Russian gas (Financial Times, 2022; Quartz, 2022; LRT, 2022d). In June, the Lithuanian parliament passed a law that prevents "countries that are deemed a threat to national security" to access Lithuania's gas grid and its LNG terminal (LRT, 2022e).

Yet while Lithuania perceived its big neighbor as a threat to national security, Germany experienced Russia from a completely different perspective. Indeed, prior to Russia's invasion of Ukraine, Germany's experience with Russia as a trading partner was overall positive. Even if Germany's "Wandel duch Handel" approach didn't bring democracy to Russia, it has facilitated Germany's reunification (Kundnani, 2014; ARD, 2021). In addition, cheap Russian gas significantly contributed to the nation's prosperity and wealth. Eager to import even more Russian gas and insensitive to East European concerns, Germany supported the construction of Nord Stream 1 & 2 – two direct pipeline connections to Russia, with a capacity that is almost equivalent to the cumulated capacity of all major land connections between Russia and Europe (i.e., $2\times55$ bcm/a versus ca. 120 bcm/a (Statista 2022 c). Blinded by hubris, Germany and the other EU Member States with vested interest in the project (i.e., France, the Netherlands, Austria,) ignored the calls against the construction of Nord Stream 2, even as Russia annexed Crimea in 2014 and escalated the conflict with Ukraine in 2015, and signed in September 2015 the shareholder on the Nord Stream 2 project (Sziklai et al., 2020, p.11). In addition, the asset-swap described in Sect. 3 granted Gazprom full control over its Europe's largest gas storage facility in Rehden (Spiegel, 2015). Thus, instead of diversifying its imports, as Lithuania did, Germany took its energy security for granted, rushing with its entire being in an even stronger dependence on Russia. Since the beginning of the Russo-Ukrainian war, Germany's policymakers are forced to resort to drastic measures to regain the nation's energy sovereignty. While Chancellor Scholz suspended for example the certification of the Nord Stream 2 pipeline, economy minister Habeck took control over Gazprom Germania. In addition, German policymakers and industrial leaders joined efforts to: (1) increase gas imports from the Norway and Netherlands; (2) forge new alliances with USA, Qatar, and other potential suppliers of gas; (3) fill up the existing gas storage facilities before the winter season; (3) accelerate the construction of three LNG terminals in Brunsbüttel, Wilhelmshaven and Stade; (4) increase domestic gas production; (5) substitute as far as possible gas with coal in the electricity sector; (6) accelerate the deployment of renewable energy; (7) build up a national gas reserve; (8) craft energy emergency plans for supply shortages; (9) decide whether to prolongate the lifespan of the last three German nuclear reactors; (10) shield vulnerable consumers against rising energy prices; (11) bail-out threatened gas companies; (12) craft a legal frame required to implement these measures (BMWK, 2022a, b & c; Agora Energiewende, 2022a & b; Leopoldina 2022). Germany's energy and water association, BDEW estimates that Germany could reduce in the short run its gas demand by one fifth, and Russian imports by about one third. If Germany can maintain the low import levels of Russian gas established by the end of 2021, the country may even half its Russian imports (BDEW, 2022b). According to the last Energy Security Progress Report Germany succeeded to rent two floating LNG terminals, expected to enter the ports of Brunsbüttel, Wilhelmshaven by the end of 2022 (BMWK, 2022c).

However, Russia drastically reduced and partially haltered the gas flow through Nord Stream 1, that makes it difficult for Germany to fill its storage facilities[8] before the Winter season (BMWK, 2022c). Indeed, although Germany's storage facilities have a total capacity that corresponds to about 30% of Germany's annal gas consumption, they were only filled at 27% the beginning of the war, which is an unusual low level, and might be related to the fact that Gazprom controlled to a large extent Germany's storage facilities (Leopoldina, 2022). The successive disruptions in gas deliveries from Russia aggravates this situation even more. Since it is not possible to rapidly replace Russian gas with renewable hydrogen, scientists from the Leopoldina Academy recommend the government to substitute gas with coal in the electricity sector and postpone the transition to a hydrogen economy (Leopoldina, 2022). Given the lack of alternatives, Germany will follow the expert advice and partially substitute natural gas with coal, putting temporarily its climate targets on the back burner. It

[8] Germany's storage facilities have a total capacity that corresponds to about 30% of Germany's annal gas consumption. However, at the beginning of the war they were only filled at 27% - an unusual low level for the winter season (Leopoldina, 2022).

will also renounce phasing out two of its three remaining nuclear facilities by the end of 2022 (FAZ, 2022b). In the meantime, Germany will import – at the pace imposed by Russia's countersanctions – as much Russian gas as possible, will complement these imports with gas purchases from other countries to fill up its storage facilities, and hope that the LNG vessels will enter on time in German ports. Yet there is still a long way to go until the country can regain its energy sovereignty.

Although Lithuania had in comparison to Germany a much higher dependency rate on energy imports from Russia (91.6% vs. 31.1%,) the country was better prepared for an energy crisis and succeeded to cut its Russian energy imports in a very short time. This comparison between Germany and Lithuania shows that energy dependency rates are alone inappropriate for comparative vulnerability assessments, and demonstrates that one country's historical background can and does significantly influence its energy security strategy and its preparedness to cope with crisis situations.

## 9 Conclusion

Almost six decades ago, when Egon Bahr presented his "change through rapprochement" concept, hoping that it would help to gradually relax the tensions between Germany and the Soviet Union, he could neither foresee that his idea will accompany in adjusted form successive generations of German politicians, nor could he assume that it will lead to Germany's reunification, let alone guess the complex geopolitical changes that will be associated with it the post-Soviet era. Yet once in the public domain, Bahr's idea developed its own dynamics, mutating from a non-ideological reconciliation attempt into an instrument for the "transformation of communist rule"(Westerwelle, 2013). The wave of enthusiasm that succeeded the fall of the Iron Curtain, seemed to mark "the end of history" and "the universalization of Western liberal democracy" (Fukuyama, 1989). In this context, trade and the mutual dependencies resulted from it have become safeguard of peace and prosperity in the world.

We have shown that German and European "rapprochement" policies resulted – despite ideological differences – in a reliable trade partnership and a long-lasting period of peace and prosperity. This overall positive experience with Russia showed that "trade and investment flows can indeed moderate the likelihood of conflict between great powers, as liberals believe" as Copeland writes in *Economic Interdependence and War* (2015, p.1).

Yet as time went by, the liberal economic thought penetrated Europe, and the EU's dependence on Russian fuels significantly increased. The fall of the Iron Curtain was followed by the reunification of Est- and West-Germany, the dissolution of the Soviet Union, and the foundation of the EU, the efforts to create a single European market, the deregulation of the electricity and natural gas markets, and the extension of the North Atlantic Treaty Organization (NATO). All these changes challenged and stressed the Russo-European relationship triggering discontent, mistrust, competition, protectionism, populist and nationalist movements and governments. By entering the EU, Czechia, Poland, Hungary, and other former satellite states of the Soviet Union could rapidly develop, while Russia lagged behind, failing to develop a competitive manufacturing sector – an asymmetry that triggered discontent on the Russian side (Tajoli, 2022). To transport crude oil and natural gas from extraction sites in Siberia to East-, Central-, and West-European countries, the Soviet Union has initiated and built a complex trans-European pipeline system. After the fall of the Iron Curtain, Russia expanded this system in cooperation with EU Member States. Yet the European rules for the deregulation of the gas market require owners of gas pipelines to grant non-discriminatory third-party-access to their pipelines. This means for example, that Gazprom must allow interested gas traders to distribute gas through its European pipeline system – a situation that offered another reason for discontent on Russian side. The emergence of energy exchange platforms allowed customers to benefit from low wholesale market prices and temporarily reduce their consumption of Russian gas (Högselius, 2013; Gustafson, 2020). Moreover, the EU's declared intention to steer the economies of its Member States away from fossil fuels does not offer Russia a reliable basis for long-term revenues from energy trades, tensioning the relation even more (Högselius, 2013; Gustafson, 2020). Emerging tensions between Russia and former republics of the Soviet Union, showed that Russia can and does use energy as a weapon against disobedience, demonstrating starkly that "interdependence can also push states into crises and wars, as the critics of liberalism contend" (Copeland, 2015, p.1).

Despite early warnings, extensive energy security plans, a vast scholarly literature about economic interdependence, Russian fuels were "too attractive to resist," and major European economies have done little to reduce their vulnerability to Russian energy imports, prior to Russia's current war against Ukraine. In *Red Gas*, Högselius (2013, p.200) describes Europe's passivity in strengthening its energy security in the following terms:

> The attempts to broaden Europe's supply base proved difficult to sustain in the face of excess pipeline capacity for imports of red gas, along with Moscow's new willingness to act as a price leader. From an economic point of view, Soviet gas was becoming too attractive to resist, and even though security arguments pointed to the necessity of diversification, gas from the Middle East, sub-Saharan Africa, and other distant regions could not be brought in without taking commercial realities into consideration (2013, p. 200).

Yet in the context of globalization, the Russian-European relationship grew beyond trade, resulting in complex juridical, economic, technological, and political entanglements that allowed major state-owned Russian corporation to control fuel storage, transport, and distribution infrastructure, as well as nuclear fuel and decommissioning services, which are all critical for the Union's energy security.

We have focused on trade interdependencies, complex entanglements, and the geo-political context that allowed Europe to become vulnerable to Russian imports and Russia to threaten Europe. We provided an overview of measures implemented to strengthen Europe's energy sovereignty, highlighting the measures implemented to sanction Russia.

We have analyzed the multifaceted implications of policy announcements related to sanctions and measures, addressing the impact of the war in Ukraine on energy prices, consumers, utilities, and European economies. We assessed the investment environment, showing that the EU Member States focus primarily on deploying renewables in the electricity sector, a focus that is necessary but not sufficient for successful energy transitions, because electricity represents only one fourth of Europe's energy consumption. Our analysis highlights major barriers to transition related to the fact that the most abundant renewable sources of energy – solar and wind – are intermittent. It addresses the lack of technologies able to store electricity at a large scale, reviews the difficulties encountered in building cross-country powerlines, and shows that political will is not sufficient to steer Europe's economies away from fossil fuels. To be successful, the deployment of renewable energies needs to be coordinated with the construction of power lines, and that emergence of new breakthroughs in storage technologies.

Our analysis was complemented with a comparative vulnerability assessment between Germany and Lithuania. This assessment starts from the dependency rates presented in Sect. 4, showing that such indicators are of little practical use for comparative vulnerability studies. Indeed, using the dependency rates shown in Fig. 5, one might conclude, for example, that Lithuania that imports 96.1% of its energy from Russia is at a much higher risk to be harmed by sanctions against Russian energy imports than Germany, which imports only 31.1% of its energy from Russia. Yet counterintuitively, Lithuania was the first European country that succeeded to fully ban Russian energy imports.

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